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ROENTGEN TREATMENT OF CERVICAL ADENITIS*†

A REVIEW OF 333 CONSECUTIVE CASES

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DURING the last year there was a notable increase in the number of patients referred for the roentgen treatment of cervical adenitis. Since beginning this type of therapy in 1903, under the direction of one of us (Pfahler), the number of such patients has totalled 269 in the hospital series and 64 in private practice. Modern technique has simplified the treatment and improved the results. The present review, we believe, will further stimulate the application of roentgen irradiation in benign, inflammatory enlargements of the cervical glands.

ANATOMY

Briefly, the lymphatics form a collar of superficial nodes encircling the neck and named respectively, the occipital, mastoid, preauricular (parotid), facial, submental, submaxillary, and the faucial and pharyngeal tonsils. All these drain into a deeper set of nodes, called the carotid, found under the upper four-fifths of the sternocleidomastoid muscle. The tonsils drain directly into the anterior carotid nodes, while the adenoids empty into the posterior set. Immediately above the clavicle are a few inferior deep cervical glands. The efferents of the deep cervical glands form the jugular trunk. On the right side, this trunk ends in the junction of the internal jugular and subclavian veins. On the left side, the jugular trunk joins the thoracic duct near its opening in the left subclavian vein.

ETIOLOGY

Among the more common causes of cervical adenitis may be mentioned tonsillo-pharyngitis, dental disease, otitis media, scalp eczema and pediculosis, scarlet fever, mumps, measles, diphtheria, and influenza. The tonsil is considered generally as the most common source of infection. Howarth[20] has made bacteriological studies of both the tonsils and the lymph nodes, and has found them less frequently involved by tuberculosis than by staphylococci, streptococci, or the streptothrix. In the individual cases he found the same organisms infecting the tonsils and the lymph nodes. In search of an explanation for this phenomenon, Wood[39] has experimentally shown the tonsillar epithelium to be unusually vulnerable to microorganisms. Both Downes[13] and Howarth[20] believe that the chronic enlargements are perhaps the result of repeated focal infections with possible secondary invasion by the tubercle bacillus. In a routine study of tonsillectomies, Pybus (quoted by Landis[21]) found 6.7 per cent of 762 hypertrophied tonsils

* The case records in this paper came from Dr. Pfahler's private office and his service at the Medico-Chirurgical and Graduate Hospitals.

† Presented by Dr. Kapo before the Philadelphia Roentgen Ray Society, October 12, 1933.

FIG. 1. Roentgenogram of same patient as in Figures 2 and 3 showing a large superficial swelling in the right cervical region associated with extensive calcification in the whole chain of glands on the right and to a lesser extent on the left.

harboring tubercle bacilli. In a series of cases of tuberculous adenitis Mitchell[23] recovered the bovine type of the tubercle bacillus in 88 per cent of the cases.

DIFFERENTIAL DIAGNOSIS

Anatomical knowledge of the lymph draining areas subserves as a guide to the probable focus causing the glandular involvement. The nasopharynx should always be investigated whenever there is cervical adenopathy present. Generally there will be found tonsillar disease, but rarely one will find a malignant nodule, which may be very small. When metastatic malignancy is suspected a biopsy should be performed after preliminary irradiation has been given. In Hodgkin's disease or lymphosarcoma, glandular enlargements may be revealed additionally in the axillae or mediastinum; the lymph nodes are more apt to be infiltrating in character and less likely to be tender. Leucemia and syphilis can be eliminated by appropriate blood studies. Necrosis and caseation occur rapidly in tuberculous adenitis and is then indicated by increased hardness or tenseness rather than softness as is popularly presumed (Bruce[7]). The roentgenographic demonstration of calcification in the lymph nodes is almost certain evidence of tuberculosis (Downes[13]) (see Fig. 1). Calcified nodules cannot be expected to disappear. Howarth says the assumption that the persistence of a chronic enlargement of the gland is due to the tubercle bacillus is valueless. Haynes[19] sets forth an exhaustive series of questions to be answered in making a differential diagnosis and finally concludes that one must frequently resort to a biopsy. Bailey[3] cautions us about the similarity of branchial cysts and certain tuberculous cervical abscesses. The constant location of a branchial cyst in the upper third of the neck under the anterior

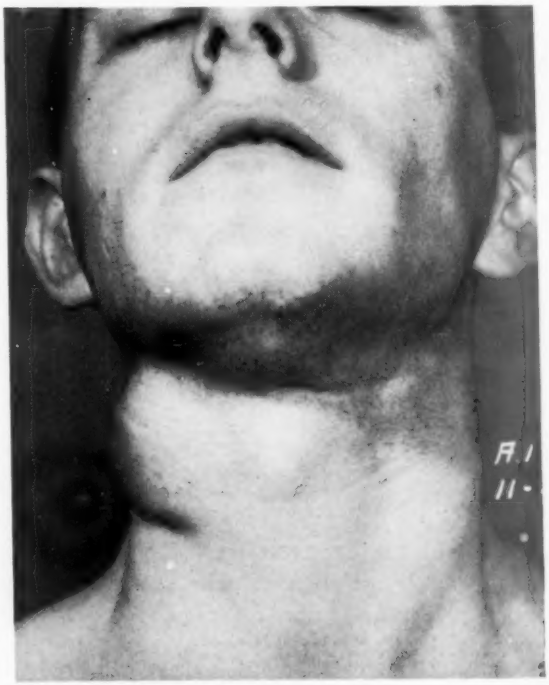

Fig. 2. Photograph made on November 28, 1930, illustrates a white male, aged twenty-two, with swollen glands in the right side of neck of six years' duration. Microscopic examination showed tuberculoses. The roentgenogram (Fig. 1) revealed extensive calcification of the glands. When referred he had a large, superficial, soft, red, tender mass in the right cervical region at the anterior end of a large scar and several sinuses. The fluctuant swelling was incised and evacuated. Four roentgen treatments totalling 200 per cent S.E.D. were given. Curettings from the sinuses yielded necrotic calcific débris.

border of the sternocleidomastoid muscle is also the most common location of tuberculous glands. Branchial cysts, however, occur rarely before the age of fifteen and most commonly between the ages of seventeen and twenty-five. They yield cholesterol crystals when aspirated.

GENERAL TREATMENT

Hygienic measures and removal of focal infections will often effect cures in acute cervical adenitis, although recurrences are not uncommon. In the treatment of chronic tuberculous forms, radical excision has become obsolete because of complicating sequelae such as ragged scars, chronic sinuses, recurrences, nerve and muscle injuries, and the occasional flaring up of tuberculous processes elsewhere (Clute;[10] Robinson[31]). Hope of cure by tuberculin injections has proved disappointing (Albert-Weil[2]). Heliotherapy, while helpful, requires six to twenty-four months of active treatment before satisfactory results are obtained (Clute[10]).

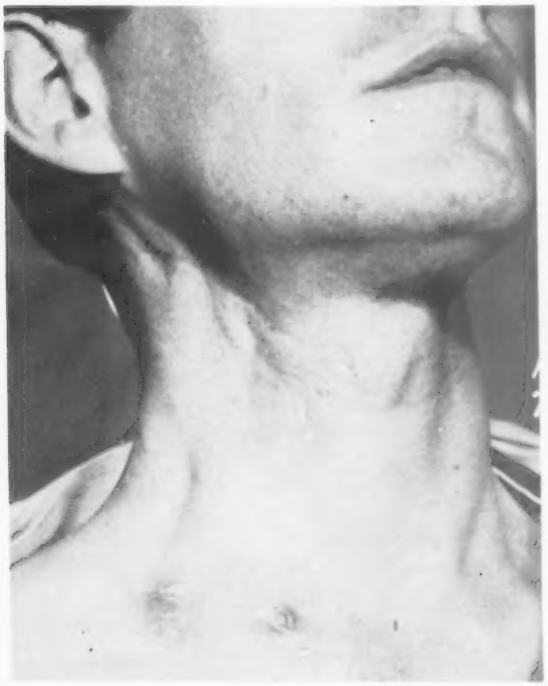

Fig. 3. Photograph taken in July, 1930, shows the original mass and sinuses healed. Several new sinuses had developed near the clavicle. Curettement was followed by three roentgen treatments. Observation on December 9, 1932, showed a most satisfactory result with all sinuses healed.

ROENTGEN TREATMENT

The uncertainties of the above-mentioned therapeutic measures appear to have been overcome by the modern methods of roentgen irradiation. Pfender[29] quotes Bergonié and Terrier as being the first to mention roentgen rays for the treatment of scrofulous lesions in 1898. Kienböck in 1900 and Aroustan in 1901 reported the results of bacillary glands treated and improved by radiotherapy, while Williams of Boston and Pusey of Chicago in 1902 were the first American writers to report on the roentgen treatment of cervical adenitis, and one of us made a report on 10 cases in 1903 (Pfahler[27]).

From uncertain beginnings the roentgen technique has developed into a highly efficient form of therapy. Many of the patients treated prior to 1922 received 30 to 40 fractional doses (each equivalent to about 10 per cent S.E.D.) over a period of fifteen to twenty months. Great advances have been made in recent years. Not only have the number of treatments been considerably reduced but the results, too, are definitely better. Of 30 patients under treatment and observation in the past two years 20 were apparently free of any swelling and the remaining 10 had improved 60 to 90 per cent when last seen. The average number of treatments given in each of these cases was four. An adult patient, who had previously spent $1,700.00 on a cancer quack, was given a perfect result in two months, during which a total of 285 per cent S.E.D. (1,710 r) was given (see Figs. 4 and 5). In several acute cases complete reduction took place within twenty-four hours after the first treatment.

Although there is a gradual resorption of the swelling in most cases, there are some which undergo resolution and become fluctuant, necessitating incision and drainage. Occasionally fibrous tissue or calcific

FIG. 4. Photograph made on March 13, 1931, illustrates a female, aged forty-eight, with enlarged cervical glands on the left side of the neck extending from the ear down to the clavicle, with a raised scar running through its center. Two years previously this patient spent $1,700.00 on a cancer quack who treated her with pastes and poultices over a period of seven months. Microscopic examination on March 30, 1931, showed tuberculous adenitis. Roentgen treatment: A total of 285 per cent S.E.D., divided into six treatments, was given over a period of forty-five days. Observation on May 25, 1931, found the patient free of all swelling and the scar was smooth.

FIG. 5. Photograph taken on August 3, 1931, shows the improved result.

remnants may require surgical excision if found to be objectionable. Chronic sinuses that do not yield to irradiation are readily made to heal after curettement and electrodesiccation of the base. Calcific deposits, acting as foreign bodies, have been found at the bottom of such sinuses.

There are no contraindications to roentgen therapy in cervical adenitis and in experienced hands there need be no complication. Carter[9] reports having observed only one case that developed telangiectasis. Our records similarly include only one case, but there were probably more that appeared after leaving our observation. This is a danger which we believe can be avoided by keeping close account of the total irradiation.

TECHNIQUE

The factors used in our present technique are a 9-inch spark gap (130 kv. p.), 5 ma., 40 cm. skin-target distance, 6 mm. aluminum filter, and 50 per cent S.E.D. (300 r). This dose is repeated at intervals of one to two weeks until the desired result is obtained, frequently requiring but two treatments, but at other times as many as ten. At present we aim not to exceed ten such applications, and at no time exceed the normal tissue tolerance or saturation value.

The treatment must be adapted to the individual, and when the lesions are large, we aim to obtain a cross-fire effect and, in this way, save the skin in every possible way. During recent years, it has been our aim to give larger doses and reduce the number of applications. This is done chiefly as a matter of economy, but we get the impression that our results are better because of this fact.

Fig. 6. Photograph of a girl, aged nine, made on March 8, 1932, before treatment, illustrates enlargement of the right cervical nodes seventeen days in duration. Roentgen treatment: Four doses of 50 per cent S.E.D. (300 r) each were given at weekly intervals.

STATISTICAL STUDY OF 333 CONSECUTIVE CASES

The earliest recorded treatment in this series was given on February 9, 1903. Females outnumbered males by a ratio of 184 to 149. The youngest patient was two weeks old; the oldest was sixty years. Seventy-five per cent were less than thirty years of age and only 9 per cent were over forty. Racially, 258 were white; 73 were black; 2 were yellow. The duration of the disease before roentgen therapy was instituted ranged from two days to twenty years. Of 244 in which the location was given, 78 were bilateral, 78 were limited to the left and 88 were limited to the right. One hundred and fifty-nine returned for observation; 7 of these were unimproved. The remaining 152 showed 50 to 100 per cent improvement, the majority enjoying complete cures. In the last five years every case has been greatly improved or cured.

In 133 a clinical diagnosis of tuberculosis was made; of these 22 were microscopically confirmed. Tonsillitis was blamed in 10 cases and dental disease in 4. Tonsillectomy and measles accounted for 3 each. Positive blood Wassermann reactions were recorded in 4 cases. In each of 8, scarlet fever, mumps, whooping cough, mastoiditis, otitis media, vaccination, laryngitis, and diphtheria preceded or was complicated by cervical adenitis.

Previous operations were performed on 49 per cent (64 excisions and 55 incisions) of the 241 patients treated before 1928; while in the last five years, of the 92 treated only 22 per cent (4 excisions and 16 incisions) had any pre-irradiation surgery.

In the accompanying illustrations are shown a few cases typical of the results obtained in this series.

REMARKS

Both the patients and the physicians,

Fig. 7. Photograph of same patient as in Figure 6, made on January 10, 1933, shows complete disappearance of the enlarged nodes. This same appearance was presented in less than two months after beginning treatment.

FIG. 8. Photograph made on June 1, 1932, illustrates a patient, aged two, with swelling of four weeks' duration below the right ear. Incision was made because of fluctuation. Swelling and sinus persisted. Roentgen treatment: 50 per cent S.E.D. (300 r) on June 1, repeated in a week. Observation on July 16, 1932, showed sinus and swelling gone.

FIG. 9. Photograph of same patient as in Figure 8, made on November 20, 1932, shows result after radiation therapy.

and the surgeons in charge of patients, have always been pleased with the results obtained in the past by means of roentgen therapy, but during recent years, the surgeons, especially, have become more convinced of the value of this form of treatment and its simplicity. The patients are usually treated without any hospitalization. The treatment is painless, though when dealing with very young children, there are often difficulties in holding the patient still during the treatment, but since we often succeed in getting the patient well with two or three treatments, this difficulty is not a serious matter. Little children can usually be bound up in a towel or sheet somewhat like a papoose and held in position by means of sand bags, which does no harm and involves no one in any danger. We aim, of course, to protect the surrounding parts of the body from any radiation or electrical effects.

It is a great pleasure to the surgeons associated as well as ourselves to see a large cervical mass soften after a few days, and often undergo resolution, and be absorbed without any operation whatever. If the glands become soft, instead of at-

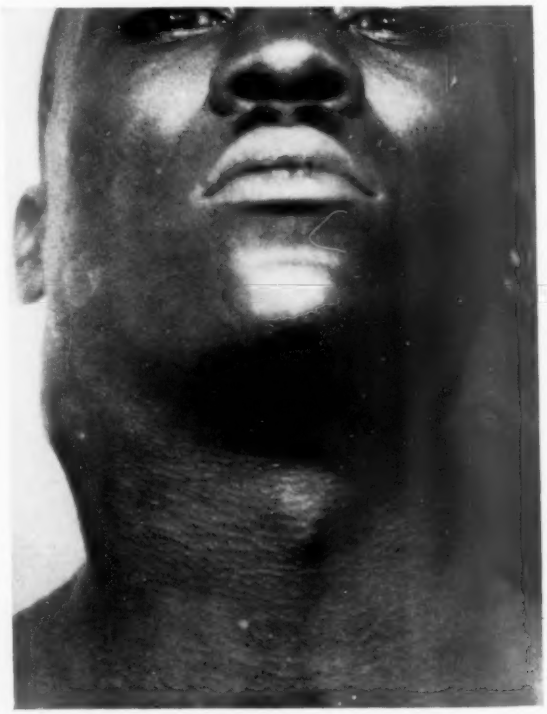

FIG. 10. Photograph made on February 1, 1929, illustrates patient, aged thirty-five, with swelling below the right ear of three weeks' duration. Suppuration and a sinus developed. Roentgen treatment: Three doses of 50 per cent S.E.D. (300 r) given at weekly intervals.

tempting a wide dissection, there is a small incision made such as would be done in treating an abscess or a boil, the pus and necrotic tissue are allowed to escape and then the wound heals up with practically no scar, and one avoids the disfiguring scars that so often follow surgical dissections. Furthermore, one avoids the red indurated sinuses that are so often associated with a prolonged surgical treatment, or after repeated surgical dissections.

Since we have been able to measure the dosage more accurately, and since we have been reducing the amount of treatment to the minimum, we have had no difficulty with either atrophy or telangiectasis. Not infrequently, radiologists forget that atrophy and telangiectasis may take place from many repeated applications of roentgen rays or radium, even though there has never been an erythema present. Atrophy and telangiectasis are really the results of an excess total irradiation, and are not necessarily due to or controlled by the amount of erythema.

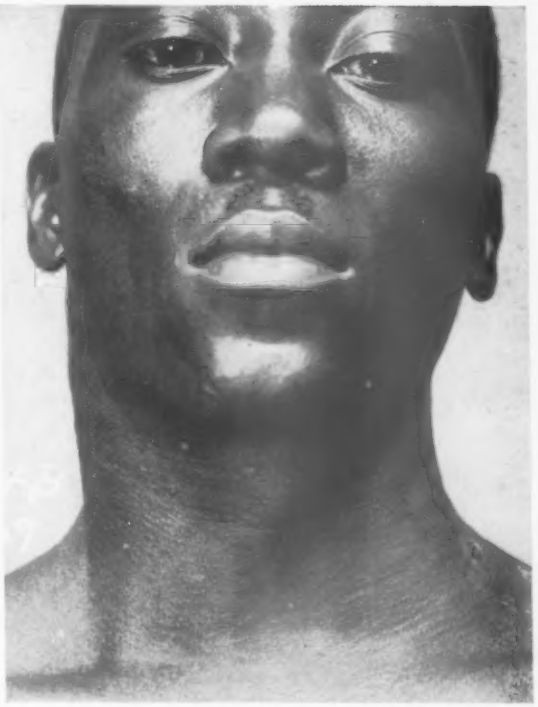

Fig. 11. Shows patient eight months later with mass and sinus healed.

SUMMARY AND CONCLUSIONS

1. This report is based upon a review of 333 cases of cervical adenitis of varying degree, both acute and chronic. Approximately 42 per cent have been recurrent cases after operation.

2. We are convinced, and our surgical colleagues are also convinced, of the superior value of roentgen irradiation in the treatment of cervical adenitis. In recent years, the majority of the patients have been referred by our surgical colleagues.

3. The treatment can be given ordinarily without hospitalization, which is especially important with young children because of the difficulties of entering children for short periods on account of the problems of contagion in infectious diseases.

4. With our present technique, the majority of the patients can probably be cured with from two to four treatments, and we aim to keep our treatments under ten.

5. With our present technique, we believe that atrophy and telangiectasis can be avoided.

6. Old sinuses and thickened red scars can be successfully treated by electrothermic destruction followed by one or two roentgen treatments.

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OBSERVATIONS ON ENCEPHALOGRAPHY

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RECENT medical journals contain numerous articles on encephalography. Perusal of these papers leaves one with the impression that much is still to be developed in this field. Articles by Pendergrass[8,9,10,11] and Pancoast and Fay[6,7] and the report of the Committee on the Standardization of Encephalography[13] have thoroughly covered the literature and beautifully presented an exposition of the relation of the neuro-anatomy to the encephalogram.

There appear, however, to be definite possibilities of improvement in the roentgenographic technique used. This is especially true in regard to positions. The vertical roentgenograms are excellent for the subarachnoidal system, while horizontal exposures appear better for the ventricular outline. There is also considerable possibility of extending the diagnostic value of the examination by establishing a more definite normal, and thereby a more accurate recognition of abnormality in terms of definite pathology. Subdural air is of special importance in this connection.

TECHNIQUE

The roentgenographic technique, as described in the articles mentioned in the first paragraph, consists in taking vertical roentgenograms with the Potter-Bucky diaphragm at a tube plate distance of 40 inches. During the past few years a large number of spinal air injections have been made at Flower Hospital by Dr. K. Winfield Ney. The technique of the injection of the air has been thoroughly described in the articles mentioned above and needs no further description. Dr. Ney uses luminal in $4\frac{1}{2}$ grain amounts every hour for two or three doses before the air injection. This appears to have one great advantage over the other hypnotics used: it stops the vomiting produced by the injection. Headache is not eliminated, but it is believed to be diminished. With this hypnotic the patient can be moved about somewhat more freely than with other forms without nausea or vomiting or too much discomfort. Not a single case of vomiting has occurred with luminal. Straining of vomiting often forces the air out of the subarachnoid space, and the severe congestion from vomiting reduces the diagnostic value of the roentgenogram. The avoidance of vomiting permits any mobility of the head and greatly facilitates the work. Review of plates before the use of luminal shows them to be inferior to the present ones, chiefly because the patient may now be better controlled.

The films taken at Flower Hospital are made without a Potter-Bucky diaphragm. Excellent detail and contrast are obtained by the use of a 2 meter tube plate distance with a small cone. Roentgenograms made with the Potter-Bucky diaphragm show a too marked distortion even with the tube 40 inches away. By the 2 meter method a comparatively accurate representation of the true size is obtained. Records of measurements of the size of the ventricles can be accurately kept by this method. The contrast of the air is equal to that on the Potter-Bucky roentgenograms. Exposures are made with 86 kv. peak and 180 ma-sec. for anteroposterior views and proportionately less for the lateral exposures. The attempt is made to slightly underexpose and overdevelop. The plates are developed quite dark bringing out the most contrast possible between air and brain tissue.

In addition to the customary anteroposterior and posteroanterior and lateral upright exposures, prone laterals are also taken to show the anterior and posterior horns, so as to obtain a comparative study of the relative size and shape of the two respective portions of the lateral ventricles.

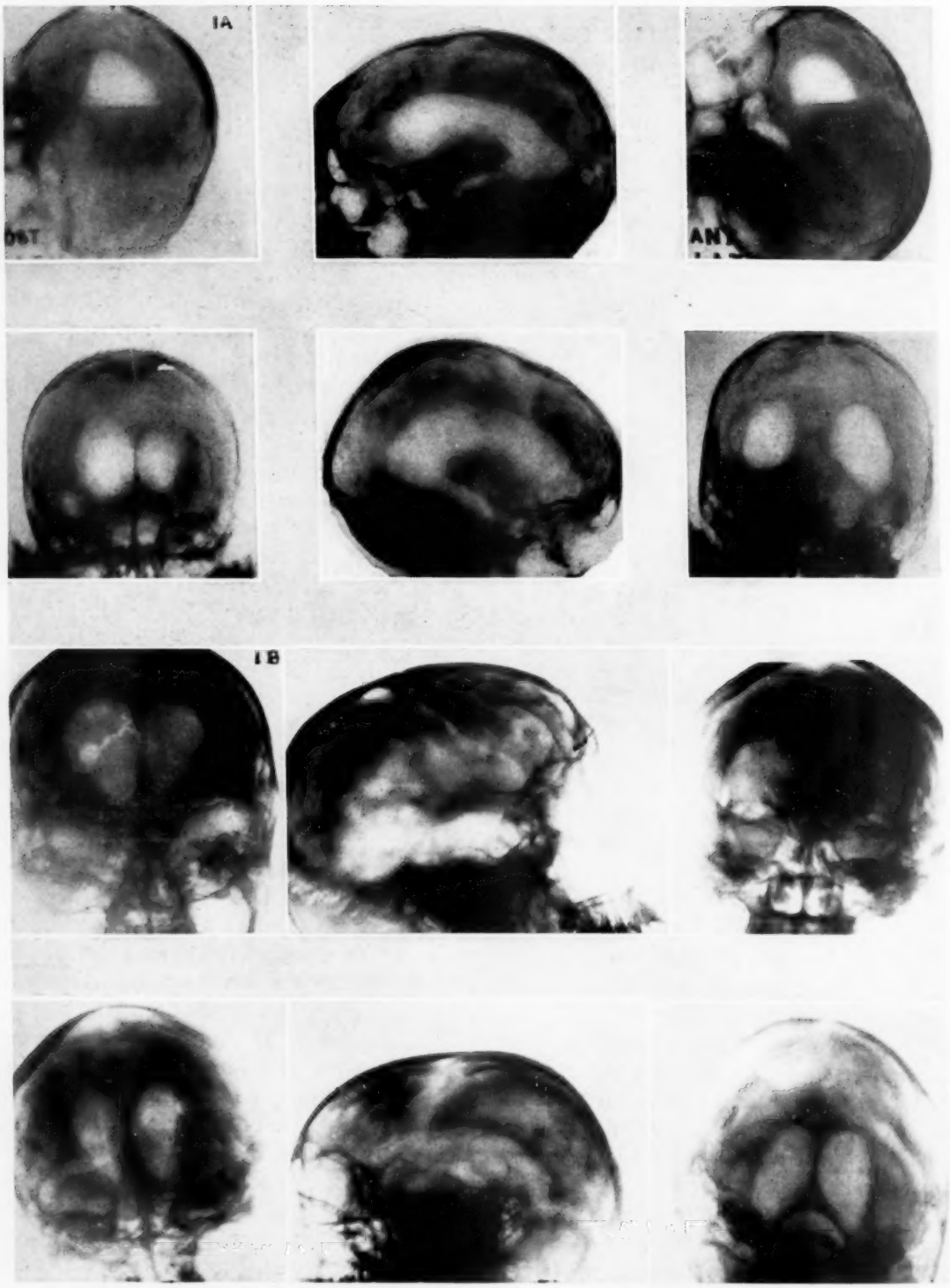


Fig. 1A. Showing the oval appearance of the horns in hydrocephalus with loss of normal angles.
Fig. 1B. Showing the wavy convolutional markings sometimes observed in hydrocephalus.

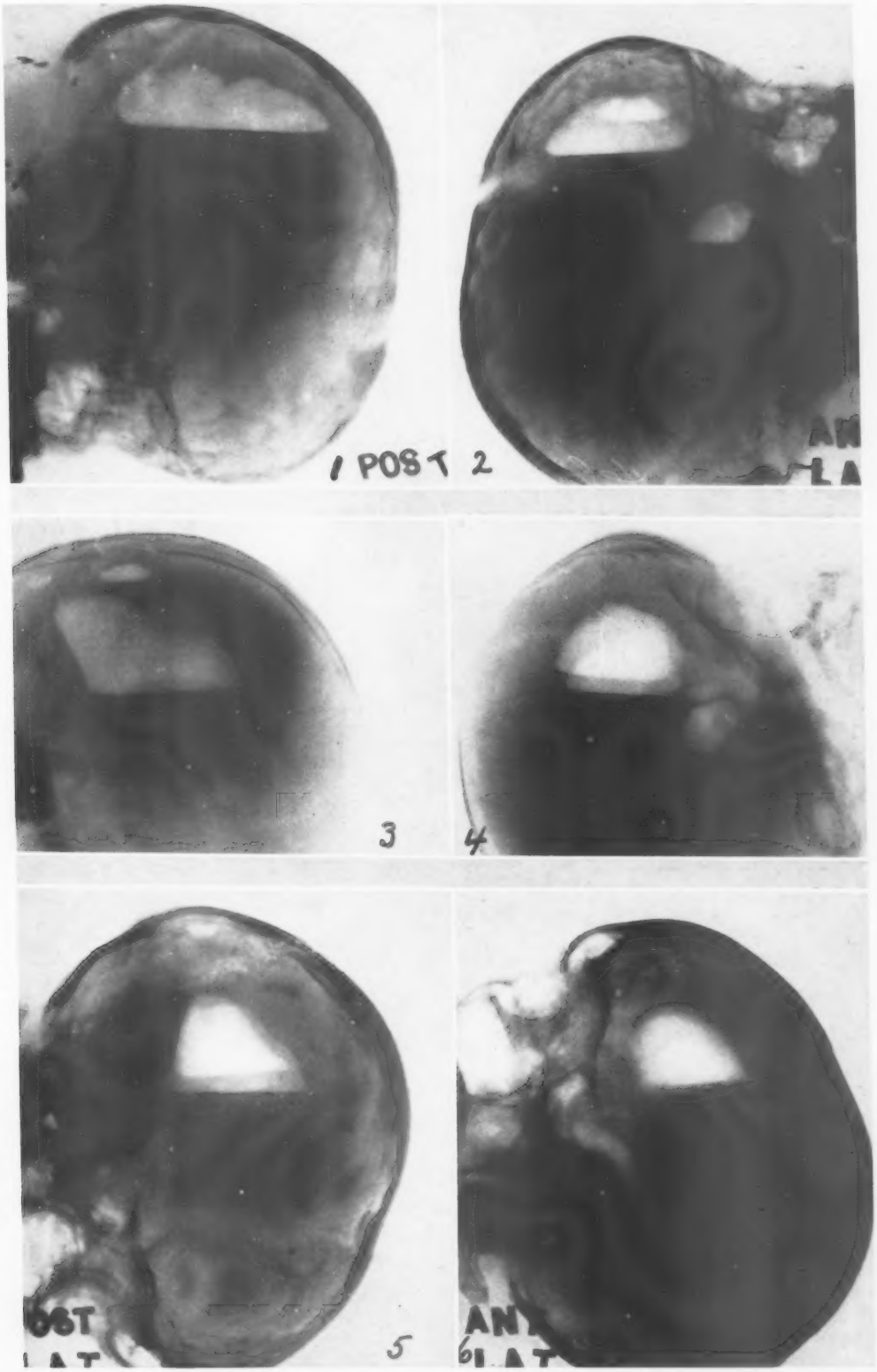


Fig. 2. Illustrating the anterior and posterior lateral views with the occiput and forehead up in hydrocephalus. Films 2 and 4 also show the anterior end of the temporal horns.

These views are shown in Figures 2 and 5. The tube being 6 feet from the plate results in very little distortion between the size of the two sides. Furthermore, it shows them both clearly. It is thus possible to get a comparative study of the relative size and position of the two sides. This has great value in the localization of tumors. The patient lies prone with the forehead resting on a small block 1 inch thick. The patient remains in this position for a short time to allow the air to ascend into the posterior horns. Then a lateral posterior horn exposure is taken with the plate alongside of the head and the tube 2 meters from the plate. The patient then lies on the back and the air ascends into the anterior horns. A lateral exposure of the

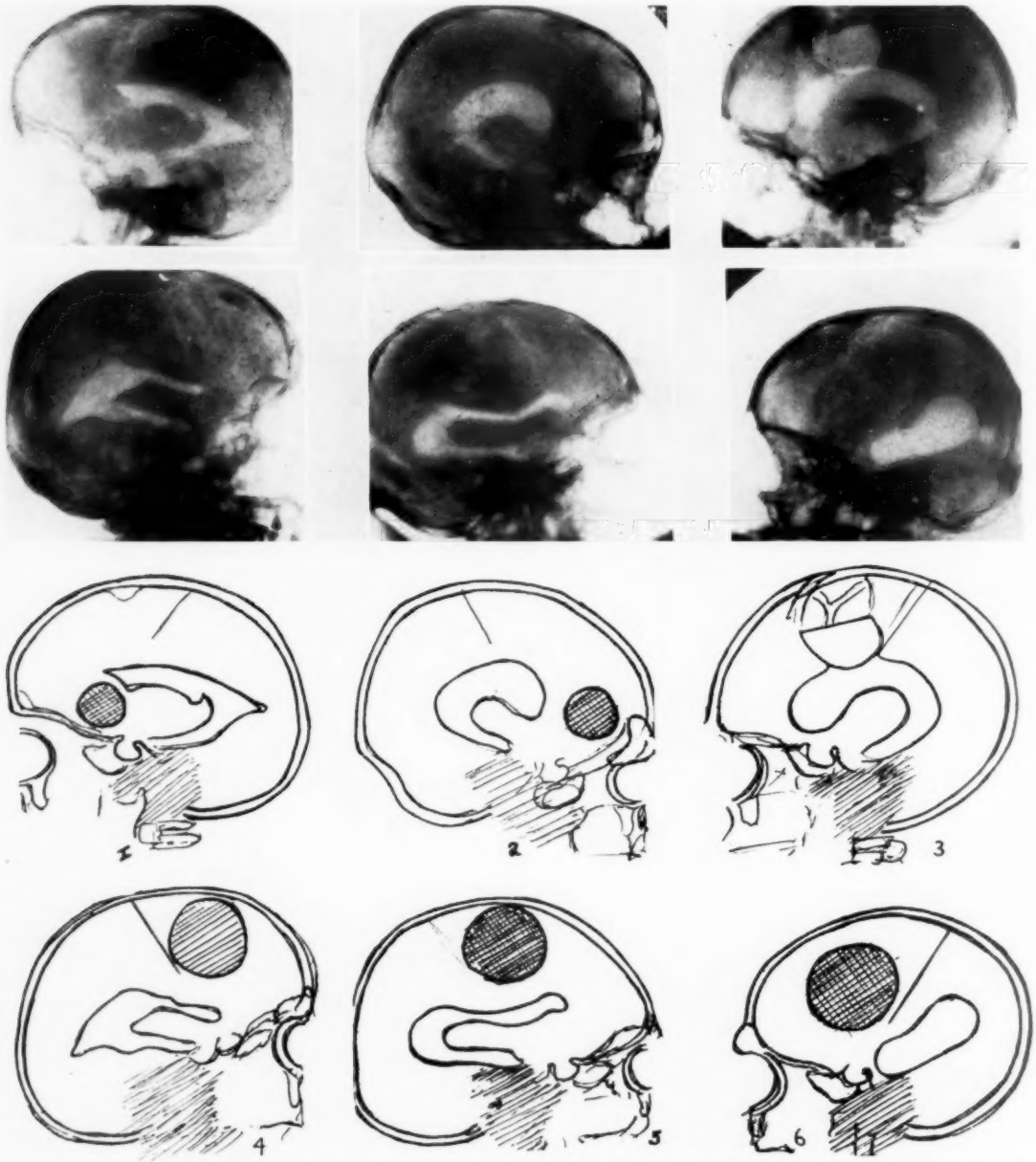


FIG. 3. Illustrating localization of tumors. Film 1 shows previous operation. Films 4 and 6 show trephine for previous ventriculography.

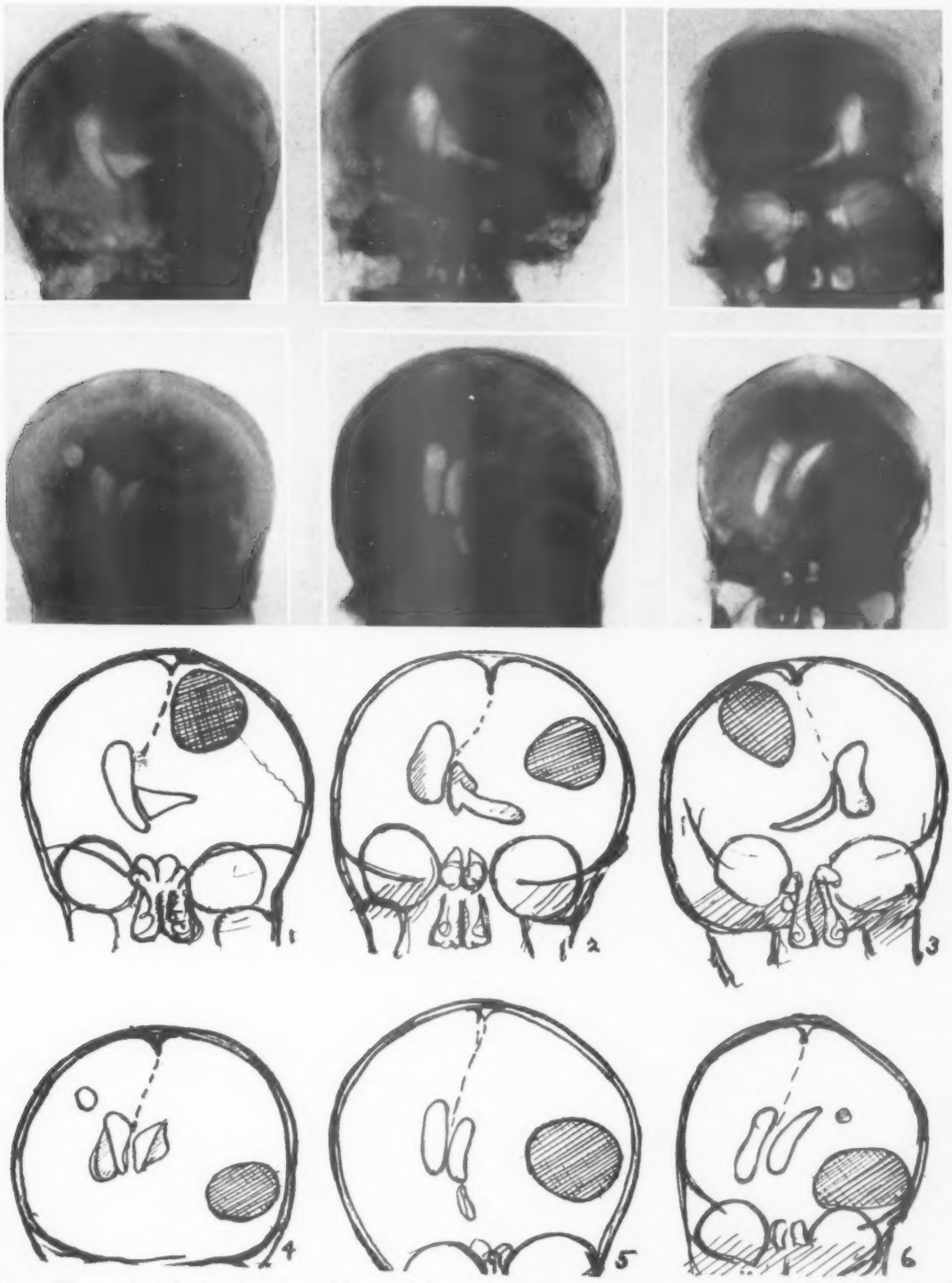


Fig. 4. Illustrating the localization of frontal lobe tumors. Film 3 is a cyst communicating with the lateral ventricle. Film 6 shows the temporal horn only, the anterior horn being completely compressed by the tumor. Considerable bone atrophy is evident in films 2 and 5. Trephine openings from a previous ventriculography are present in 1 and 6.

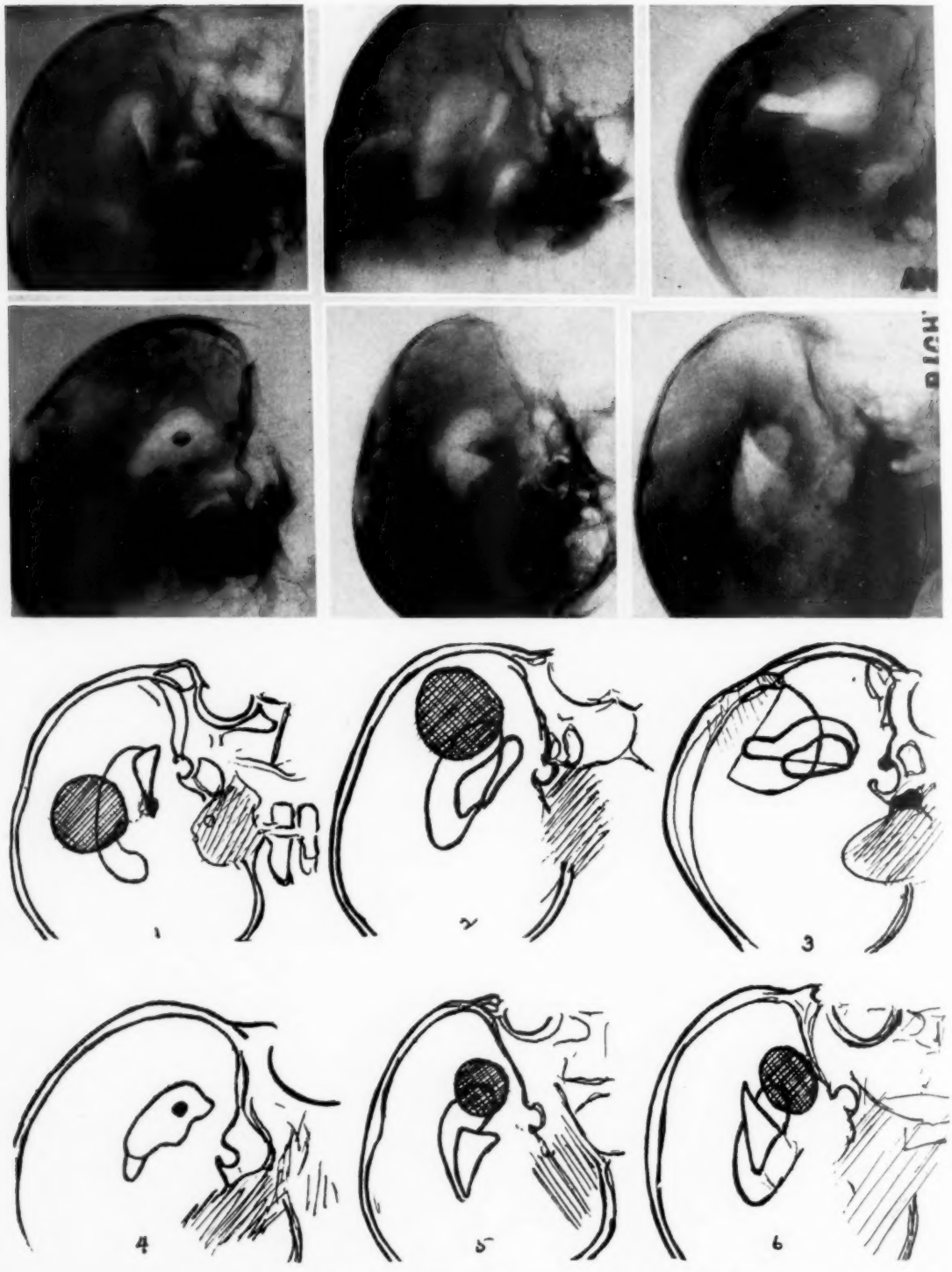
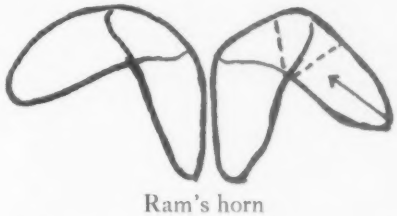


Fig. 5. Illustrating the lateral anterior horn exposure with localization of frontal lobe tumors. Film 3 shows a cyst communicating with the anterior horn of the ventricle. Film 4 shows a pearl body in the ventricle.

anterior horn is then made. Finally, direct lateral views are made with the patient lying on the side. It is preferable to have the plate over the head and the fluoroscopic tube is centered from below. The air ascends into the uppermost ventricle which will be nearest the plate. The distance here cannot be 6 feet, unfortunately. Finally, anteroposterior and posteroanterior plates are made with the patient lying horizontally, and with the tube beneath and the plate on top. This makes a series of ten plates or more, since usually more than one exposure is made in the various positions. The air does not go well into the posterior horns in the upright position unless they are completely filled.

Butterfly view



Ram's horn

1. The relation between the anteroposterior diameter of the skull and the distance from the anterior horn to the tip of the posterior horn.
2. The depth and width of the anterior horns as shown in the posteroanterior view.
   (*a*) By an oblique line from the extreme tip of the wings.
   (*b*) The widest point perpendicular to this line.
3. The greatest depth as observed in the anteroposterior view.
   Choose the widest point for measurement.

DIAGNOSIS

The diagnostic findings of these encephalograms should naturally convey the information desired by the neurological surgeon. The value of this examination depends on the close cooperation of the roentgenologist with the neurologist. It might be helpful if the approximate size of the ventricles could be measured and classified as larger or smaller than the average. It has been said that we cannot state the exact normal size and shape, and variations within normal limits, of the ventricles for the reason that normal individuals are not submitted to such a procedure. However, an approach to this problem can be made by measurements in those cases which are considered to be normal. These measurements must be based on the lateral, posteroanterior and anteroposterior views. What diameters to select as most apt to reveal the difference between normal and pathological must first be decided upon. Examination of the encephalogram shows an extremely large number of possibilities which might be of value. For the purpose of simplicity, however, and as a suggestive beginning for such measurements, the following have been selected:

These measurements were selected because they appeared to show the greatest distortion between the normal-shaped ventricle and the changes occurring in early cases of hydrocephalus. The recognition of comparative degrees of hydrocephalus by this method might have a distinct value. The information, however, obtained by measuring cerebrospinal fluid pressure would have greater value in determining the degree of hydrocephalus.

It is, of course, as has been stated, impossible to obtain a normal average size unless encephalograms are made on normal individuals. This is obviously impossible. However, in going over a series of cases, a certain number are classified as negative. In the series at Flower Hospital about 30 per cent were considered negative from the standpoint of ventricular deformity, thereby definitely ruling out the question of an expanding intracranial lesion: hydro-

cephalus, brain tumor or abscess. Measuring these in accordance with the diameters just described revealed that the length of the ventricle was about 10 cm. less than the length of the skull, within 0.1–0.2 cm. For example, the length of the skull from the outer plate of the frontal to the occipital just above the inion might be 21 cm., and the length of the ventricles 11 cm. An insufficient number of infants and children were tabulated to give any measurement. The above appeared to apply to adults, male and female. The depth in the posteroanterior view (the *a* line) varied from 2.5 cm. to 3.5 cm. and the width (the *b* line) from 1 cm. to 1.3 cm., depending again on the size of the skull and brain. The depth in the anteroposterior view varied from 1–1.3 cm.

It is questionable whether a change in the actual size of the ventricle is as important as a change in the contour of the ventricle. When the ventricle begins to enlarge from the internal fluid pressure of a hydrocephalus it loses the normal angular appearance and becomes oval (see Figs. 1 and 2). The *b* line is invariably lengthened in hydrocephalus. The other diameters are also proportionately enlarged. It must be remembered, however, that a ventricle may enlarge to compensate for a loss of cerebral substance, as for instance after the removal of a cerebral tumor or in atrophy. This ventricular enlargement would give an appearance suggestive of hydrocephalus, but without an increase in cerebrospinal fluid pressure. Compensatory changes in the ventricular and subarachnoid system therefore take place in a cerebral defect. The characteristics of such a compensatory enlargement is a loss of angular contour of the ventricles as in hydrocephalus, but also with an enlarged subarachnoid space which is evident by large accumulations of air in the cerebral sulci in that particular region. Thus a combined enlargement of both ventricular and subarachnoid space is pathognomonic of cerebral atrophy or destruction.

Displacement and filling defects of the ventricles indicate the presence of a tumor or some other localized expanding lesion, and give definite localization of the lesion. It is essential that the neurological surgeon know exactly where a tumor is located in order to plan a successful surgical exposure. This is particularly true in subcortical tumors when at operation the surface exposure fails to locate the position of the tumor, and in frontal lobe tumors where the neurological localization is at best very indefinite. A roentgenological aid which definitely shows the surgeon that the tumor is in the frontal region of a certain hemisphere, which is often impossible without such assistance, and which shows definitely that the lesion is above, below, lateral or in front of the anterior horn makes the whole difference between success and failure in accurate localization in this silent area of the brain. In consideration of this particular area we are submitting a series of roentgenograms of frontal lobe tumors which demonstrate the possibility of exact localization, which would be totally impossible by present neurological methods (see Figs. 3, 4 and 5).

The question of air in the subdural and the subarachnoid space leaves room for much further study. A recent article[12] gives a report of a case showing a large amount of air in the subdural space. One week later this same case was reinjected and the air was in the subarachnoid space. A second case showed normal subarachnoid cortical markings immediately after injection, while twenty-four hours later the air was entirely subdural. This subdural air was regarded as an error in surgical technique permitting the primary entrance of air in the spinal subdural space at the point of injection. The fact that this is occasionally observed in plates made the following day indicates the possibility that there may be another explanation of this finding. If air were injected in the spinal subdural space, it would tend to ascend soon after injection rather than wait twenty-four hours before making its appearance. In our series of cases subdural

air has only been found in cases of so-called cerebral atrophy commonly found in epilepsy (see Fig. 6) or in definite cerebral atrophies associated with vascular lesions, as for example a thrombus of the middle cerebral artery. In such conditions there is usually a marked reduction in the cerebrospinal fluid pressure. Since many of our encephalograms are made for the determination of a possible pathology in epilepsy this is an extremely important point. The frequency of its occurrence in these cases suggests a relation between the two. These cases are apt to have a diminished spinal fluid pressure which also appears to have a bearing on the condition. Dr. Ney is inclined to think that there might be an escape of air into the subdural space through a defect in the arachnoid primarily around the enlarged Pacchionian granulations, which are extensively found in these cases. The sequence thus suggested might be cerebral atrophy with compensatory enlargement of ventricular and subarachnoid spaces and a compensatory increase in fluid although without an increase in fluid pressure.

Notkin[5] reports that over 50 per cent of epileptic cases examined show either dilatation of the ventricles or meningeal adhesions, or dilatation of the subarachnoid space, with enlarged Pacchionian granulations. No reference was made to subdural air. Fay [1,2] discusses at length the dilatation of the subarachnoid spaces with an increase in cerebrospinal fluid in epileptic patients. On the basis of faulty fluid eliminating mechanism of the subarachnoid villi, and the Pacchionian bodies, the dehydration theory is founded.

Therefore, the size and extent of the Pacchionian bodies is an extremely important part of the roentgen report. These are demonstrated roentgenographically by areas of local bone atrophy of the inner table of the skull on either side of the sagittal suture. These vary greatly in size. The visualization of these depressions is somewhat uncertain unless series of plates are taken at different angles. A sagittal section

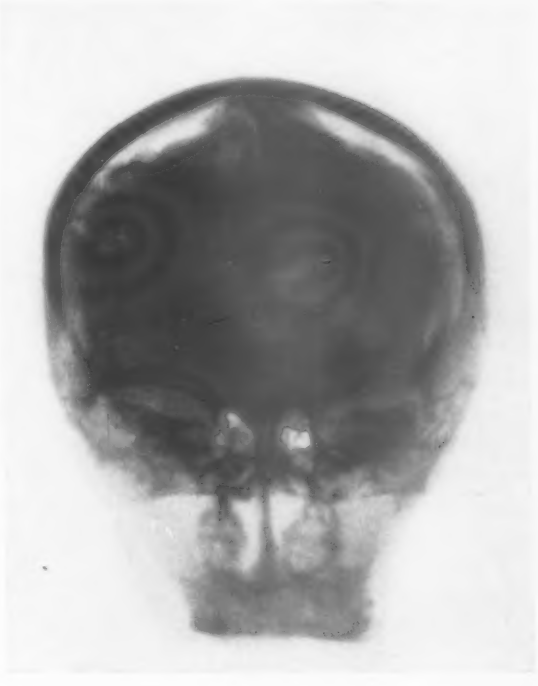


Fig. 6

of the skull is shown on the roentgenogram only in one plane. A series of these sagittal sections are necessary to visualize completely these areas of bone atrophy. Usually our series of twelve or more plates is sufficient for this purpose unless special study is desired. Generalized bone atrophy as seen in Figure 1B is pathognomonic of hydrocephalus. This is shown roentgenographically by extensive convolutional markings impressed on the skull giving a wavy appearance. Local bone atrophy is also very important in diagnosis and localization of brain tumors. Nothing absolutely characteristic, however, is found in bone atrophy over the site of a tumor. The affected area may be circumscribed so as to give a punched out appearance, or at times it shades off so imperceptibly that it is difficult to ascertain its exact limitations. It may show localized convolutional markings as differentiated from the generalized appearance of hydrocephalus. In the frontal region of the skull extensive thickening of the inner table has frequently been observed. This often appears to be located

about half an inch to either side of the midline and have a rounded area of increased density. Calcification is also frequently observed in the falx cerebri.

CONCLUSIONS

1. Luminal is an excellent hypnotic for encephalography.

2. Vertical encephalograms are best for subarachnoidal visualization; horizontal views as outlined are best for ventricular visualization.

3. Combined enlargement of both ventricular and subarachnoid space is pathognomonic of cerebral atrophy or destruction.

4. Definite localization of frontal lobe tumors is extremely valuable to the neurological surgeon.

5. Subdural air shows a definite pathological condition and is associated with decreased intracranial pressure. It is found in epilepsy or cerebral atrophies due to vascular lesions. It may be due to an arachnoidal defect around enlarged Pacchionian granulations.

6. Observation of bone atrophy is very important in diagnosis of epilepsy or expanding intracranial lesions.*

I wish to express sincere appreciation to Dr. K. Winfield Ney for his cordial assistance in the preparation of this report, and for permission to present his ideas herein contained.

* Since this paper was submitted for publication a number of modifications and new procedures in technique have been made. These will be incorporated in a new article which will appear in an early number of the Journal.

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Vol. XXXII, No. 3

ENCEPHALOGRAPHY*

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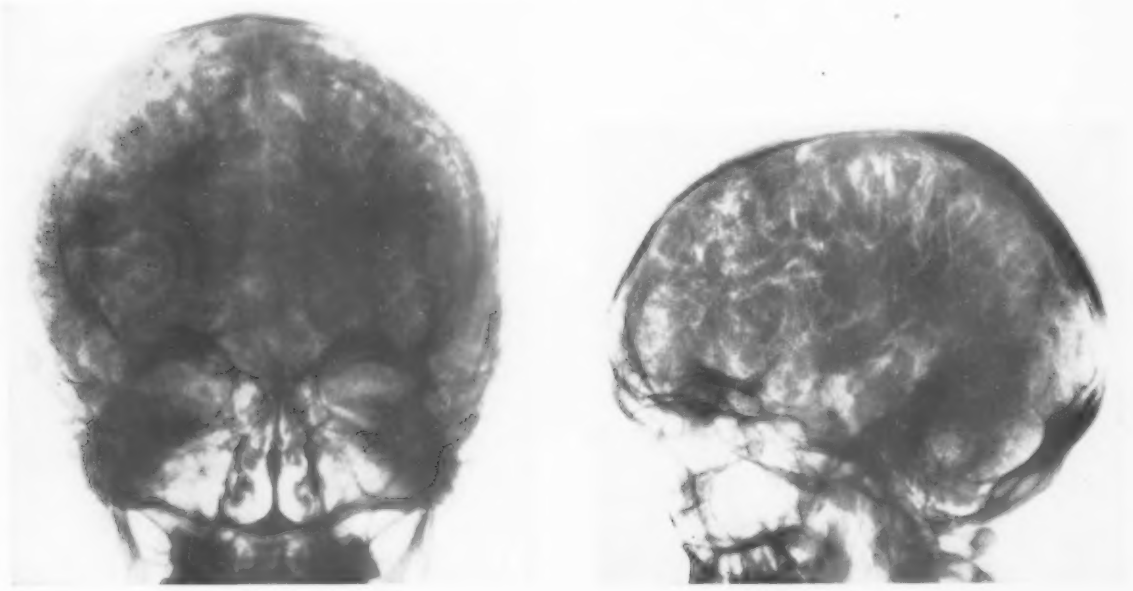
ENCEPHALOGRAPHY is being widely used as a diagnostic procedure. It is proper, therefore, to consider the technique of producing an encephalogram, how errors may be avoided, and what findings on the films must be considered abnormal.

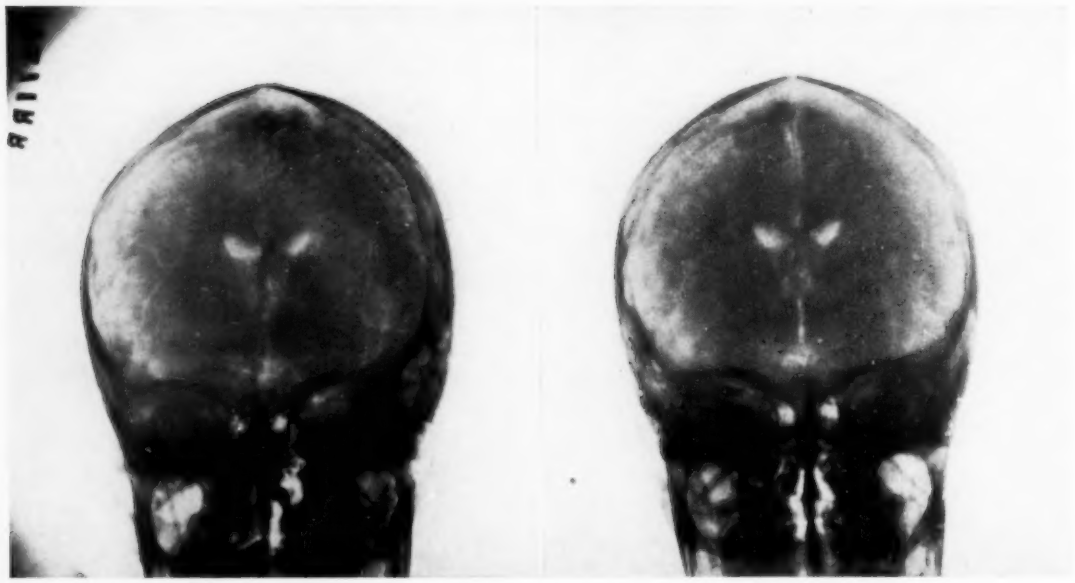
A diagnosis is reached in encephalography as a result of three maneuvers: the removal of the fluid and its replacement by air, the filming of the head and the interpretations of the roentgen findings. In the first of these three maneuvers, the cardinal principle is complete removal of all fluid. It makes little difference what method is used, whether two needles[1] or one, whether air or more readily resorbed gas is employed.[2] But unless the subarachnoid spaces and the ventricles are completely and thoroughly drained, the air shadows seen on the films will not accurately represent their size, shape and position. Experience shows that frequent anteroposterior and lateral rotation of the head, pressure over the jugulars and voluntary straining on the part of the patient are necessary to obtain complete drainage. The patients are no more uncomfortable if the fluid is removed rapidly or slowly, or whether or not an attempt is made to keep the spinal pressure at a definite level by replacing the fluid volume for volume with air. Actually at the conclusion of the fluid-withdrawal air-injection the spinal tension always approaches zero, as the air is in the subarachnoid space under approximately atmospheric pressure.



A B

FIG. 1. F. C. Essential epilepsy. Initial pressure supine 180 mm. of water; 160 c.c. of fluid removed; 150 c.c. of air injected. In this case one might have expected from the amount of fluid and air interchange that a satisfactory encephalogram would have been produced. However, it will be noted that although the subarachnoid spaces and all of the cisternae are well filled neither of the lateral ventricles nor the third ventricle seems to have air within them. A. Anteroposterior view. B. Lateral view.

* Read before the American Congress of Radiology, Chicago, Ill., Sept. 25-30, 1933.



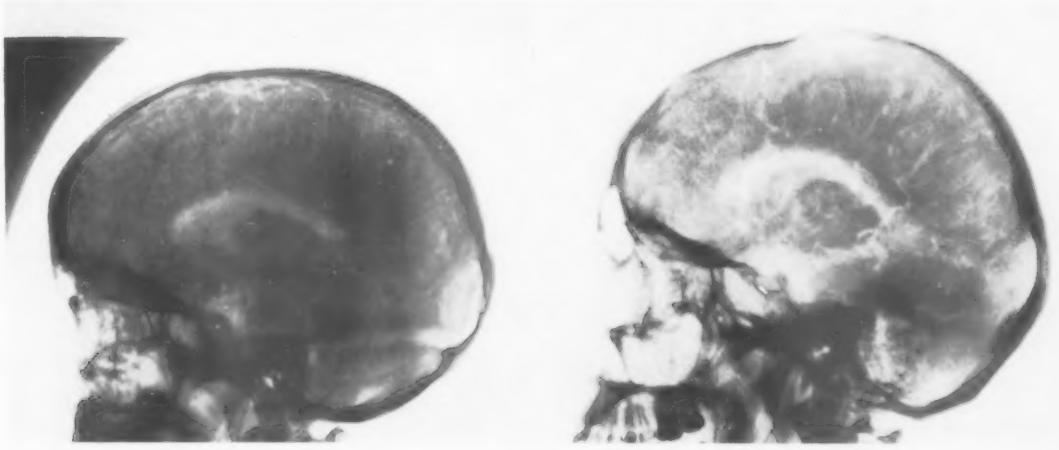
A B

FIG. 2. To show the effect of slight rotation of the head on the outline of the ventricles in the anteroposterior roentgenograms. A. Head rotated slightly to the right. Note that the film suggests that the left lateral ventricle is enlarged and appears to have been pulled out toward the cortex, suggesting the possibility of a cortical scar. B. Second exposure properly centered. Showing ventricles to be normal and symmetrical.

FIG. 3. Improperly taken anteroposterior film. The head has not been sufficiently flexed so that the shadow of the orbit and frontal sinus falls over the shadow of the ventricles.

An encephalogram is always a disagreeable procedure for the patient no matter what technique is employed. Large doses of sedatives before and afterwards are essential. Therefore, every effort should be used to obtain complete drainage so that a repetition of this unpleasant experience will not be necessary. It is freely admitted that in roughly 5 per cent of cases, no matter how thorough the attempts to drain fully the fluid spaces, the films will show that this has not been possible. No explanation is put forward for this fact. In certain cases only a limited amount of fluid can be obtained, in others the fluid will escape freely and a complete drainage with excellent films is anticipated, but subsequent study shows that the ventricles are entirely undrained.

The technique described by Pendergrass[5,6] has been used in obtaining the films. It is unnecessary, therefore, to do more than point out the importance of careful adherence to this technique. In the anteroposterior and posteroanterior exposures the



A B

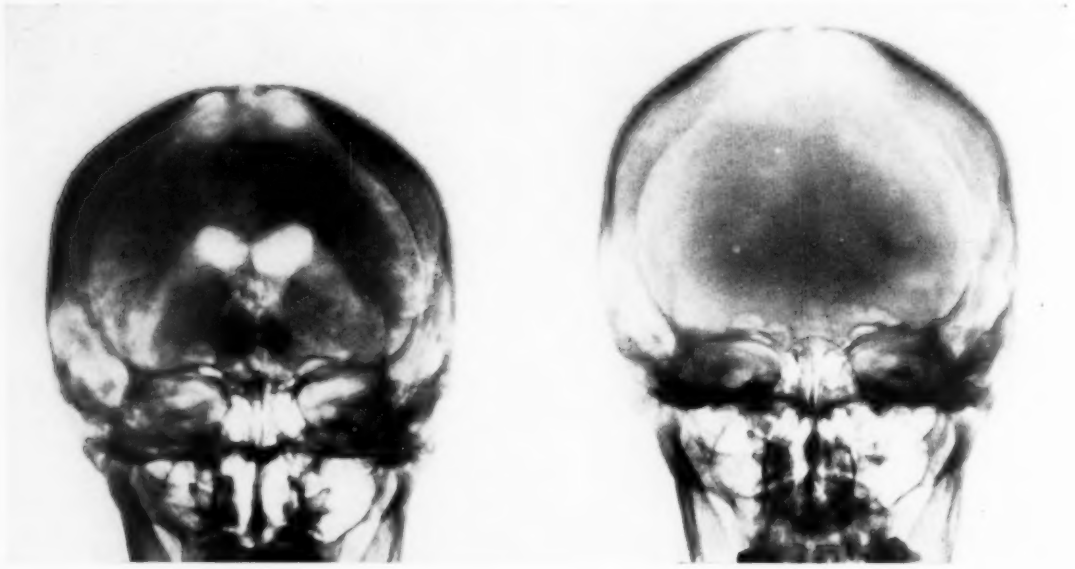
Fig. 4. A. Normal film taken in erect position. Note the posterior horns are not filled. B. Encephalogram taken in the ventriculogram or horizontal position showing good filling of the posterior horns.

head must be exactly centered to avoid distortion of the air shadows. The head should be semiflexed to throw the outline of the frontal sinuses below the level of the ventricles. In the lateral views the central ray from the tube should pass through both external auditory meati. Exposure in the erect position is much the simplest method of obtaining films, although in this position the posterior inferior horns of the ventricles are not well outlined. To permit air to reach these areas, the technique used in ventriculography is necessary with the patient in the horizontal position. An added film in the occipitomental (Towne) position is suggested. This affords an excellent view of the lateral and third ventricles together with the basilar cisternae in the horizontal plane, giving a further check on their size, shape and position.

Interpretation of encephalographic findings is tremendously handicapped by lack of normal standards. Little or no knowledge exists of normal variations, especially in the size and position of the subarachnoid spaces. Encephalograms performed upon the same individual at different times under apparently normal conditions may vary markedly in the size and distribution of the shadows representing the subarachnoid spaces. Post-mortem confirmations of encephalographic findings are meager. Furthermore, as far as the subarachnoidal and basilar cisternal changes are concerned, these spaces are unavoidably drained of their fluid at necropsy so that comparison of their actual size with the shadows attributed to them on the films is very difficult.

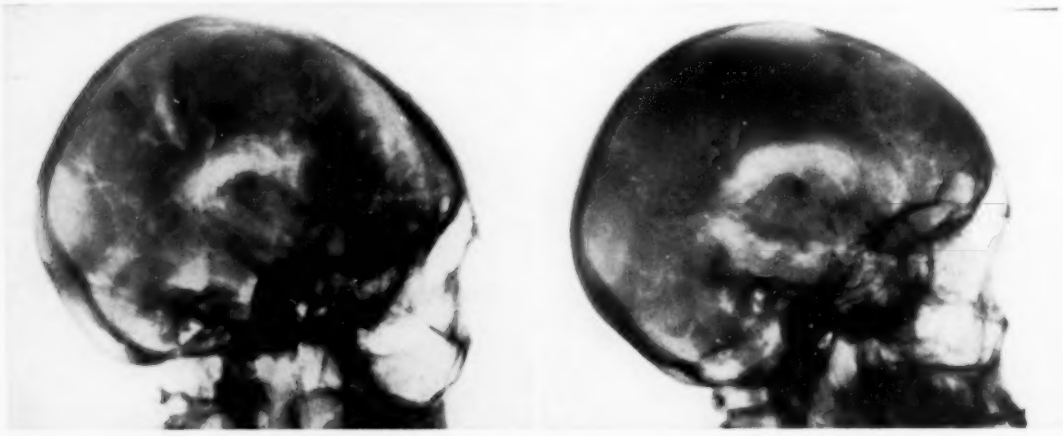
Fig. 5. Encephalogram taken in the Towne position showing outline of the lateral and third ventricles in the horizontal plane.

Encephalograms are being offered as evidence of cranial pathology in patients suffering from post-traumatic headache, dizziness, etc. Unless the abnormalities are very marked or one side much more involved than the other, especially if the variations are more pronounced upon the side of the injury, it seems quite impossible justifiably



A B

FIG. 6. A. Encephalogram in the anteroposterior view showing symmetrical dilatation of the ventricles with what appears to be symmetrically placed air-filled spaces lying to either side of the midline. B. Flat plate of the same patient showing that what is apparently air over the cortex is actually an artefact. These films emphasize the necessity for comparing flat skull plates with encephalograms before reaching a final diagnosis.



A B

FIG. 7. Films showing difference in encephalographic findings in the same patient at different intervals. A. Shows encephalogram made February 24, 1931. Initial pressure supine, 180 mm. of water; 160 c.c. of fluid removed; 160 c.c. of air injected. Note apparently marked cortical atrophy. This case suffered from essential epilepsy. B. Second encephalogram performed March, 1933. Initial pressure supine, 180 mm. of water; 170 c.c. of fluid removed; 170 c.c. of air injected. Note that there is much less evidence of cortical atrophy and that the basilar cistern and particularly the fourth ventricle are less well filled.

to support the claim that the trauma is the cause of the presumed pathology. If the sufferer shows a mild or moderate generalized symmetrical increase in size of the subarachnoid channels and ventricles, how can one be sure that this is not a normal condition for this particular individual and that it did not exist long before the trauma occurred? The same is true for idiopathic or post-traumatic epilepsy. Recent studies[4] have shown that the severest types of either variety of epilepsy may occur with an apparently normal encephalographic picture while marked changes in the air shadows, evidence of severe and widespread damage to the brain, are accompanied by mild convulsive seizures.

The therapeutic value of encephalography is extremely doubtful except in the relief of post-traumatic headache.[7] In this, at times extremely annoying condition, lumbar air insufflation may be surprisingly beneficial. In epilepsy, whether idiopathic or post-traumatic, relief following encephalography alone is the exception rather than the rule. In brain tumor suspects, es-

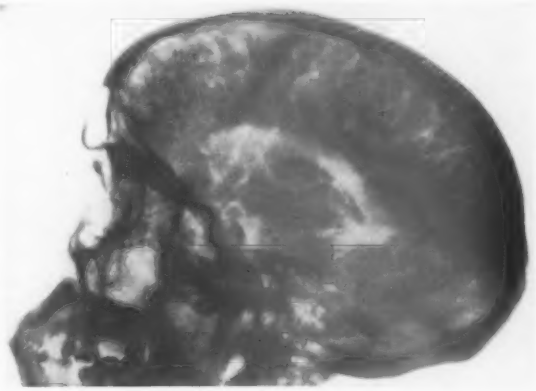
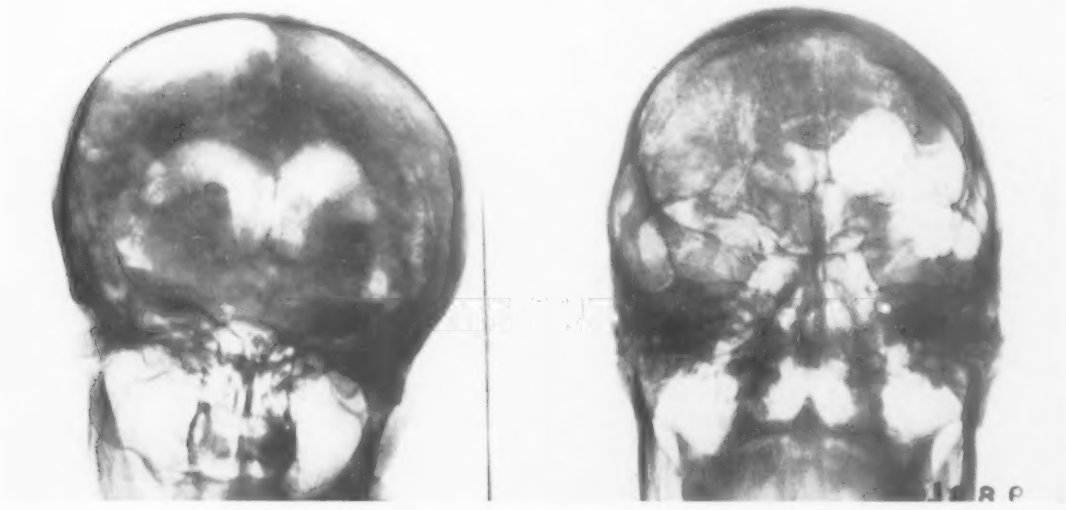


Fig. 8. J. W. Post-traumatic headache. Patient had blow to the back of the head eight months ago followed by unconsciousness lasting not over a minute. Spinal fluid clear when lumbar puncture was done six hours following injury. No neurological signs at any time. Eye grounds normal. Encephalogram March 21, 1929. Initial pressure supine, 180 mm. of water; 150 c.c. of fluid removed; 150 c.c. of air injected. Medicolegal question raised as to whether moderate changes seen on the encephalogram could have been due to mild head injury of this type. Encephalogram shows moderate symmetrical ventricular dilatation with slight cortical atrophy.



A B

Fig. 9. Films to represent types of lesion in which the encephalographic findings are so positive that no room for doubt exists as to the presence of an abnormality within the brain. A. Anteroposterior view of patient with markedly dilated ventricles with cortical atrophy and large area of subdural air over right cortex. B. Anteroposterior view of large porencephalic cyst involving the left lateral ventricle.

pecially when the lesion is in the posterior fossa, encephalography should be avoided if the spinal pressure in the prone position be over 250 mm. of water or if other evidence of intracranial pressure as choked disc is present. Although a recent report by Gardner[3] states that he has localized a number of tumors successfully in this way, nevertheless we are sufficiently old-fashioned to believe that a lumbar puncture in the face of increased intracranial pressure is dangerous. And if a simple lumbar puncture may be disastrous, encephalography must be doubly so.

Encephalography demands an exact, careful technique if films upon which a diagnosis can be based are to be obtained. The one most important factor is complete drainage of all the fluid. Ventricular distortion, marked generalized or asymmetrical atrophy or arachnitis in the subarachnoid spaces may be easily recognized. But in the finer diffuse changes, mild or moderate atrophy, before any pathologic significance is attached to this finding, it must always be remembered that it may be a normal variation, that the individual may have relatively large subarachnoid spaces or that a very complete drainage and perfect filling may make it seem that the spaces are somewhat increased over what has been assumed to be normal.

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COMPARISON OF ROENTGEN-RAY DENSITIES WITH PULMONARY PATHOLOGY*

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MORE than thirty years of intensive roentgenologic study of chest conditions has permitted me to see many theories and claims exploded and many facts established. Some of these are called to your attention, a few are emphasized, others explained and some controversial statements of today are noted and left for future determination.

This is not a statistical study taken from the literature, but rather the gleanings and experiences of an "old-timer," who pays most attention to tuberculosis. References are not given, and only a few authors are referred to personally, as the time is short and the subject vast.

The roentgenoscope was the first point of attack. Dr. Francis H. Williams, of Boston, showed most graphically what an important part the diaphragm movements play in the diagnosis of tuberculosis. Percussion had demonstrated this previously, but the roentgenoscope, so wonderfully adapted to the study of motion, proved the findings beyond a doubt. The mistake was made by some that restricted diaphragm movement must be shown on one side, or tuberculosis should not be diagnosed. As this was incorrect, it led to serious errors.

The next mistake was to diagnose tuberculosis by evidence of calcified lymph nodes in the hilus, and calcified areas in the lung fields. Today we know that calcification in the adult indicates previous infection, by which the individual's resistance to infection has been increased, and must be looked upon as vaccination against tuberculosis rather than evidence of tuberculous disease. In children under twelve, we must be most cautious. Although the vaccination has taken place, it is possible that only a low grade of immunity has been established, and some activity may lurk in the system unidentified. Childhood tuberculosis is a controversial subject at the present time, and much exact study is necessary before we may state many facts about it.

At the Hamilton County Tuberculosis Sanatorium we consider caseocalcareous lymph nodes as indicating tuberculous infection with serious clinical significance. If we were able accurately to identify all caseous lymph nodes, our problem would be comparatively simple, but we are not always able to do so, because many other infections produce enlarged lymph nodes. When the lymph node is only partially calcified, especially around the periphery, as shown by many sections, such a node contains much caseation which has not been healed by calcification, and is a serious lesion. Also we look upon all areas suggesting pulmonary exudate, whether in the apices or bases, as potentially tuberculous, but we condemn a diagnosis of tuberculosis from such findings, unsupported by other evidence. Many such areas clear up in a few weeks or months, and we have no evidence that they were due to tuberculosis. When areas of pulmonary exudate are associated with caseocalcareous lymph nodes, they do not clear quickly as we have proved many, and I believe all of them, to be due to tuberculosis. The proof is made by subsequent history, the development of calcification in the lung tissue after the exudate has been absorbed, by finding positive sputum, or by guinea pig inoculation. Without such proof it is unwise to diagnose pulmonary exudate as due to tuberculosis.

There are more kinds of pulmonary inflammation which cause exudate, simu-

* Read before the American Congress of Radiology, Chicago, Ill., Sept. 25–28, 1933.

lating tuberculosis, than we know. Malignancy may simulate pulmonary exudate as well as cause it. But this is not much of a problem in the child.

Finally, caseocalcareous lymph nodes can frequently be accurately diagnosed upon the roentgenogram in the child and the adult, and when found they have serious clinical significance. Especially is this so when they are associated with one fan, which is an area of pulmonary exudate. If there are two or more fans of different ages, as shown by different densities, then a diagnosis of pulmonary tuberculosis can be made without the node findings and when associated with completely calcified nodes. Young persons under twenty-five have a much better chance to recover from pulmonary tuberculosis when the lymph nodes are calcified completely. Thus the character of the calcification should be studied. It helps to make the diagnosis and prognosis of your patient, but the old idea that calcification alone indicates serious tuberculous infection has been exploded. Our life insurance companies have spent much time and money establishing this point alone.

At one time some authors thought that they could distinguish the individual tubercles and small conglomerations of tubercles on the film. From this we had the diagnosis of peribronchial and peritruncal tuberculosis. This led to many errors and I believe such diagnoses have been abandoned.

The greatest advance in reading chest roentgenograms came after 1910, when the stereoscopic chest plates became a fact, and were generally adopted. They lend themselves to an accurate study of much of the anatomy and enable the physician to locate the various lobes. This is especially important because the upper lobes and middle lobes are in reality anterior lobes, and the lower lobes are posterior lobes. Localization is accomplished by locating the related right and left bronchus and their branches, to the right and left pulmonary arteries, and following the trunks to their anterior or posterior destination. To do this, stereoscopic films are necessary. The art was not sufficiently advanced until about 1910, to permit stereoscopic chest exposures to become routine. Since then the art and study have advanced by leaps and bounds. The intensifying screen has added greatly to the art, but it is frequently used when better films can be made without it.

Cavities were shown so clearly on our early roentgen plates that we often teased the skilled clinician who thought he could always, or almost always, detect cavity by physical signs. The best clinicians found that they could not do this, but did us a good turn by questioning our frequent diagnoses of cavity. They called most thin-walled cavities annular shadows, and claimed that they were due to a pleural air-pocket, i.e., a localized pneumothorax. At once many accepted the challenge, and studied necropsy material to determine what besides cavity could cause annular shadows.

My findings have been that most annular shadows seen on chest films of patients with positive sputum are due to cavity and should be so diagnosed. Emphysema is the greatest exception. Some have been due to large areas of emphysema when the lung structure has broken down, as shown by my case published by William Snow Miller in a recent issue of the *American Review of Tuberculosis*. One of our recent autopsies, which had shown distinct evidence of cavity on the film and positive sputum, was found to be an area of good lung completely surrounded by tuberculous exudate. This film and sections are on exhibit. We have never found an annular shadow due to a localized air pocket. This is important because most annular shadows indicate cavity of such a character that pneumothorax or other collapse therapy should be instituted at once.

Having touched upon emphysema, let us consider it now. Emphysema is a very important sequel of tuberculosis and all other chronic lung infections as well as anthracosis and siderosis. It is associated

in some degree with all cases of arrested tuberculosis. Prior to 1890 much was written on this subject, and I can add very little to what Jenner has written. Since the use of the roentgen ray very little has been written on emphysema. It deserves much more consideration by the roentgenologist. He can detect it in its early forms, if he will learn that the barrel-shaped chest is not an essential. He must also realize that emphysema frequently plays a serious part in chronic sinus infections, pneumoconiosis, severe gas exposure, as in war, and all forms of chronic lung infection, especially tuberculosis. Many cases suffering from emphysema are treated or discharged as neurosthenics. It should be looked for routinely. It is often the only roentgen finding in asthma, gas poisoning, bronchitis and sometimes in bronchiectasis. Sometimes pulmonary hemorrhage is due to emphysema when neither tuberculosis nor bronchiectasis is present.

In a recent paper I have called attention to the injection of lipiodol in diagnosing emphysema. Only time and its use by others can establish its value.

Siderosis deserves special mention. We are indebted to Pancoast for his excellent work in differentiating this disease from tuberculosis by roentgen findings, and he has shown its association with emphysema. Patients with this disease are greatly handicapped throughout life, even after they leave the dusty trades, and are fortunate if they do not develop tuberculosis.

Pleural effusion and fibroid pleurisy require little consideration here. I wish to emphasize that caseous pleurisy is commonly overlooked, and can be mistaken easily on the film for pleural effusion or carcinoma of the pleura. It is often seen with few lung changes and these may have none of the appearances of pulmonary tuberculosis. It is a serious condition, always fatal so far as I know, and most easy to overlook. Fortunately, it is not very common among our white population.

Malignancy of the lung and pleura should be a monograph of itself. You are all familiar with the spherical densities of sarcoma and secondary carcinoma of the lungs. I venture to emphasize those forms of malignancy which simulate tuberculous adenitis of the bronchial nodes, miliary tuberculosis and pneumonic exudate.

At a previous convention I showed sections of the lung which on the roentgenogram closely simulated, and had been diagnosed as miliary tuberculosis. No trace of tuberculosis could be found, and carcinoma was in every part of each lobe. Here we exhibit a case of carcinoma, showing cavity, which I diagnosed pulmonary exudate, and because positive sputum had been reported twice (not from our laboratory, however) the lung was collapsed. The lungs and lymph nodes were most carefully sectioned and searched, and as I said, no tuberculosis could be found.

This is only one of many cases which teach us the danger of drawing unjustified conclusions, and I wish to say here that I believe such unjustified conclusions are now being drawn from some of the studies of childhood tuberculosis. In this case pulmonary exudate was simulated by a density due to malignant cell infiltration, and not to inflammatory exudate.

If carcinoma can mislead us so completely, it is easy to see how the numerous non-tuberculous infections can cause pulmonary exudate, which will simulate tuberculosis. Such cases cause one to doubt the non-virulent types of pulmonary tuberculosis, with exudate, which are referred to in the literature today. We need more proof, and time will give us that.

Finally, I wish to emphasize the importance of studying all cases which show roentgen densities suggesting pulmonary exudate with homogeneous densities, by every means at the diagnostician's hand. History, symptoms, physical signs, repeated sputum examinations, blood examinations and all other means at our disposal must be used, because after all of these we are frequently baffled. The necropsy is a great satisfaction to the doctor, but not comforting to the family.

Syphilis of the lung must be considered with great caution by the roentgenologist until the pathologist knows much more of its pathological anatomy than is general knowledge today. We have many curious lung densities in patients with four plus Wassermann reactions, which clear up under antiluetic treatment. These are not uniform and have no common characteristic density. A diagnosis of syphilis of the lungs is not justified at the present time. This is so because similar densities clear up without such treatment or appear on chest roentgenograms of patients who have no evidence of syphilis, and do not give a positive Wassermann reaction. There is much of lung pathology we do not know, and caution must be our watchword.

Thoracic surgery has given new impetus to roentgenologic chest study. The surgeon requires accurate localization. This requires excellent stereoroentgenograms of the chest. I will not take time to discuss this old subject, but wish to emphasize the fact that many physicians and some roentgenologists do not know when their films are properly placed in the stereoscope. Unless the doctor knows by looking in the mirrors whether or not the films are properly placed, and knows whether the patient has moved, he is not getting the ultimate benefit from such a study. Allowing patients to breathe between exposures has led to many errors. The practice should be condemned.

The use of iodized oil injections has been a great help. Primarily it has shown to some the value of stereo chest plates, and has demonstrated lung anatomy to many who have grasped it for the first time. We believe that it is, as I have said, valuable in demonstrating emphysema. It has proved its value in showing bronchi closed by malignant growth and the accompanying atelectasis. In bronchiectasis it is always useful in diagnosis and often helpful in treatment. It will only rarely demonstrate cavity unless injected after the bronchus leading to the cavity has been cleared by the use of the bronchoscope. I must warn you that some physicians do not know this, and claim a cavity does not exist because the oil did not fill it.

Inflammation is the cause and explanation of all the various and varying densities which we see on the films of our tuberculous patients. Inflammation due to tuberculous infection varies primarily because the virulence and quantity of the infectious virus varies, and because the number of times an individual is reinfected varies. Also because some persons have more resistance to the infection than have others. Thus we have the seed and the soil and the seedlings to consider. Where the seed is less numerous, less virulent and less frequently sown, of course the inflammation is less virulent and the pulmonary exudate is less extensive. Scar tissue, i.e., the connective tissue of repair, is more easily formed, and we call it the fibrotic type of tuberculosis. On the other hand, where the seed is very numerous, very virulent and frequently sown, we have a very virulent type of infection or inflammation, with a large amount of pulmonary exudate. The exudate may flood a large part of one lobe or several lobes. Such cases are termed the basal type, or the pneumonic type of tuberculosis. In the former, which is the commoner type, we have only areas of lobular pneumonia. This is the fan type. The different times of infection are shown by fans of different densities and different degrees of contraction. This type can be diagnosed by roentgen study alone, because, as I have tried to show, pulmonary exudate may be caused by other infectious organisms and can be simulated by carcinoma.

The fan type or apical type of tuberculosis is a curable infection if properly treated. This is the type which German authors are calling subclavicular tuberculosis. In this term they are trying to show that it does not start as apical tuberculosis suggests, but lower down in the upper lobe. So far this is correct, but when they call it subclavicular instead of subapical, they make a grave mistake. Subclavicular sug-

gests an infection in the anterior part of the lobe, while these infections start most often below the apex, but posteriorly, or toward the lateral wall. This was carefully described by Birsch-Hirschfeld in 1898, and he named the bronchus which led to the infected area, the postapical bronchus, and showed lungs taken from a man killed in an accident to demonstrate his observation. This mistake—subclavicular tuberculosis—would never have been made had the authors thereof studied stereoscopic films, and verified their observations by necropsy.

Caseation rapidly follows in both the fibroid and exudative forms of tuberculosis. Cavity follows caseation. In the fibroid type the cavities at first are small and may not be detected on the film. Cavity always exists with positive sputum. Such cavities are closed by the connective tissue of repair, and if they later break down, it is often because many small cavities have broken into each other. Such cavities have thick walls. In the exudative type large and small cavities may occur quickly. They have thin walls. There is little scar tissue at the time the abscess forms. These are rarely detected except by the roentgen ray. Collapse therapy is indicated as soon as they are formed and found. They are always associated with positive sputum. Pulmonary exudate with positive sputum, even without roentgen detection of cavity, indicates immediate collapse, because a tuberculous abscess is breaking down.

Hematogenous tuberculosis and endogenous tuberculosis are receiving much attention. It is certain that tuberculosis infects man both from without and within, but just how much we have of either is not known and I know no way of accurately determining this point. When the problem is finally solved, I am certain that roentgenologic studies will play a very important part.

Many important topics have not been considered in this paper. This is because I hope the better to emphasize the few points which I consider necessary to present-day work. The greatest of these is the necessity to look for emphysema, and in the study of roentgenograms of tuberculous patients to determine the relative amounts of scar tissue, called fibrosis, but better understood as repair tissue, and the pulmonary exudate, better called pneumonia, which indicates recent and severe inflammtion. By such a study, especially of serial films, you can determine the favorable or unfavorable progress of the inflammation and often the proper treatment. In the near future, I believe that all forms of pneumonia associated with cavity will be collapsed. Stereoscopic films are of great value, but they are not the only exposures necessary for chest study. Above all, when interpreting chest exposures rather underread than over-read your findings. Never guess. An unreliable laboratory report is misleading and hinders rather than helps the clinician. This is most important when reading chests of children. In this field many claims are made which have not been proved.

Sensitized paper, like the fluoroscope, is useful, but is not our best means to study the subject of tuberculosis in the child.

As I said at the beginning, more than thirty years of intensive study is my only excuse for these didactic statements of facts and opinions here most respectfully submitted.

GIANT EXCAVATION AND EMPHYSEMATOUS BULLA MISTAKEN FOR PNEUMOTHORAX*

A REPORT OF TWO CASES

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THE TWO cases presented here were thought to be of interest because of their clinical and striking roentgenological resemblance to pneumothorax. One is a case of tuberculous vomica occupying amost an entire lung, while the second is a case of an immense emphysematous bulla. In both instances autopsy was performed. A casual search of the literature revealed that Wilson[1] reported a case of emphysema of similar severity; the patient was still alive when the report was made.

CASE REPORTS

CASE I. J. B., male, aged nineteen, was admitted to the State Sanatorium in January, 1932. Past history was negative. The patient began to cough in December, 1930, but he continued to attend to his regular employment until June, 1931. At that time the patient began to note that he was short of breath. He did not recall whether this symptom appeared suddenly, but it was sufficiently marked to cause him to give up his work. About the same time, he began to lose weight and strength. The patient denied any history of pleurisy or hemoptysis.

Physical examination revealed emaciation, slight cyanosis and moderate dyspnea. Pulse was rapid and fever reaction marked. Medium moist râles were heard over the entire right lung anteriorly and posteriorly. On percussion of the left lung anteriorly and posteriorly, hyperresonance was elicited over the upper two-thirds and flatness at the base. Breath sounds were absent over the left lung and a metallic tinkle was heard over the same lung.

Figure 1 is a reproduction of the roentgenogram of the chest on admission.

Tubercle bacilli were found in the sputum. Other laboratory examinations showed nothing of significance.

The following diagnosis was made: Exudative tuberculosis throughout the right lung with excavation in upper lobe; hydro- or pyopneumothorax, left. It might be added that the presence of pneumothorax was questioned by only one member of the medical staff.

An attempt was made to aspirate air from the supposed pneumothorax cavity, but the patient became markedly dyspneic and cyanotic and the attempt was not repeated. The disease in this patient ran an active and rapidly progressive course and he died on May 30, 1932. It is an interesting observation that hemoptysis did not occur throughout the course of the disease.

Autopsy Findings. The upper lobe and most of the lower lobe of the left lung were found transformed into a single giant excavation—a mere "shell" of the lung. Except at the base, the wall of the cavity was notable for its uniform thinness and almost complete lack of lining pulmonary tissue—the wall was thought to average about 6 mm. in thickness. The cavity itself measured 26×12.5×11 cm. in size and communicated with the upper main bronchus. There was no record as to how much of the bronchial tree had eroded. The lowermost base of the lung, upon which the excavation rested, was consolidated, fibrotic, excavated pulmonary tissue 6 cm. in thickness. The scanty pulmonary tissue lining the excavation was definitely the seat of numerous small tubercles; at the most dependent part of the cavity a small amount of necrotic débris was found. The right lung showed extensive tuberculous lesions with cavity formation.

Microscopic examination confirmed the gross observations. An early tubercle formation was found in several of the sections but there was no way of determining their location in the gross. Caseating tubercles lined the lumen of the excavation. Extensive fibroblastic subpleural change was noted.

CASE II. S. M., male, aged forty-nine, was admitted to the State Sanatorium in August,

[1] Wilson, J. A. Obstructive emphysema. AM. J. ROENTGENOL. & RAD. THERAPY, 1927, *17*, 432–436.

* From the Rhode Island State Sanatorium.

1933. Past history was negative. Onset of present illness began in March, 1931, with shortness of breath as the most prominent symptom. About the same time the patient began to have a productive cough, loss of appetite, weight and strength. A diagnosis of "asthma" was made and upon the advice of his physician, the patient went to Arizona. During his stay there he regained some of his weight and strength, but dyspnea continued to disable him. He returned home and then entered the Rhode Island State Sanatorium.

Physical examination revealed sibilant and sonorous râles over the entire area of both lungs anteriorly. Posteriorly, crepitant râles were heard over the upper third of the left lung and sibilant and sonorous râles over the remainder of the posterior chest. Breath sounds were suppressed over the right middle and lower lobes anteriorly and posteriorly. The patient was emaciated and moderately dyspneic; the respiratory difficulty was both with inspiration and expiration. Pulse and temperature were normal.

Figure 2 is a reproduction of the roentgenogram of the chest on admission.

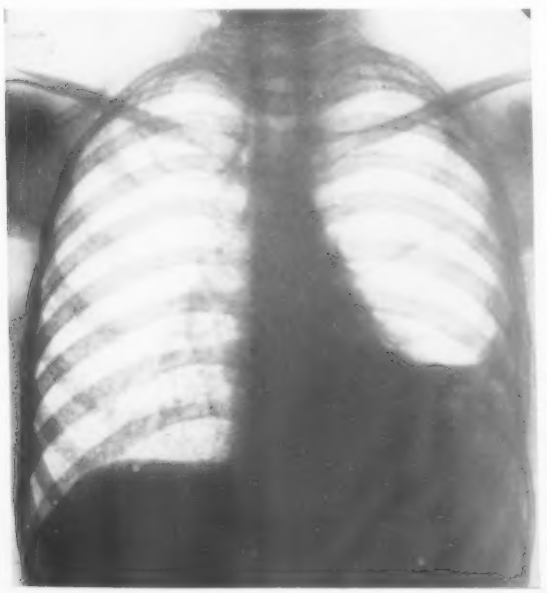

Fig. 1. Case I. From the roentgenogram, the left side was interpreted as the seat of pneumothorax with fluid level. Autopsy showed giant excavation with fluid in cavity. Right lung shows disseminated tuberculous infiltration with excavation in upper lobe.

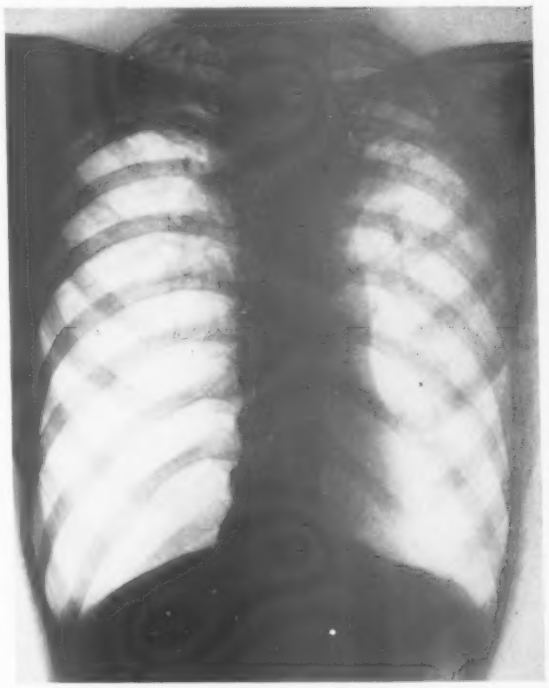

Fig. 2. Case II. Area of decreased density over right middle and lower lobe interpreted as pneumothorax. Autopsy showed immense emphysematous bulla. Fibrotic type of tuberculosis both upper lobes.

Tubercle bacilli were found in the sputum. Other laboratory examinations were of no significance.

The following diagnosis was made: Tuberculosis, essentially fibrotic, both upper lobes; pneumothorax, right; bronchial asthma?

On October 24, 1933, 800 c.c. of air was removed from the supposed right pleural cavity. The initial manometric reading was $-1+4$ and the final reading was $-4-2$. Following the aspiration of air the patient's dyspnea was relieved until the following morning. At that time, 2,000 c.c. of air was withdrawn from the right chest. The patient again obtained immediate relief. He remained comfortable until about 3 o'clock of the same day, when he experienced a sudden, sharp pain in the right chest. The dyspnea reappeared and within a short time became marked. A cannula was inserted into the sixth right interspace in the anterior axillary line, in the supposed pneumothorax cavity, and for a time the patient's condition seemed to improve. Dyspnea, however, returned, and despite continuous use of

the cannula, the patient's condition grew progressively worse and he died on October 29, 1933.

Autopsy Findings. Instead of the supposed pneumothorax, a giant, dilated, air-containing bulla was found. It found its origin from the upper border of the lower lobe, in the midclavicular line, by means of an air-containing pedicle 3 cm. in diameter. The sac spread downward, thus occupying the space intervening between the lung and the diaphragm. This space measured 9 cm. in its vertical diameter. The portion of the sac adjacent to the lateral chest wall had been punctured by the cannula. The sac was a fibrous structure 2 mm. in thickness. The lining of the inner aspect of its wall was composed of wide-meshed, stringy, emphysematous tissue. Bronchioles, too, descended in the inner aspect of the sac, extended beyond the zone of emphysematous tissue which surrounded them, and ended at the bottom of the sac as naked bronchioles. Proximal to the pedicle of the bulla was a shallow blind ending, the base of which was non-emphysematous pulmonary parenchyma; it was without direct communication with the bronchial tree. Subpleural and interstitial emphysema was present throughout the two upper lobes. Subpleural emphysema was also found along the free border of the other lobes of both lungs. Some of the blebs were 10 mm. in diameter; they averaged 4 to 6 mm.

Section of the lungs showed that most of the emphysema was adjacent to, and intermixed with, tuberculo-fibroid disease of the upper lobes. These lobes were shrunken and the overlying pleura was densely fibrotic. In addition to the dark, consolidated, fibroid patches and predominant widespread emphysema, there were numerous white, partly calcified, fibrous nodules, 2 to 5 mm. in diameter. The bronchial tree of the upper lobes appeared to be reduced in caliber.

Microscopic examination showed a typical picture of emphysema. The tuberculosis was for the most part of the tuberculo-fibroid type with a complicating picture of recently formed young tubercles. The fibrous sac was lined exteriorly with hypertrophied mesothelial cells and interiorly, in its upper half, with emphysematous pulmonary tissue.

Diagnosis: Tuberculo-fibroid disease, both lungs with compensatory emphysema; massive emphysematous bulla originating from the lower lobe, right.*

COMMENT

In the first case, physical examination was of little aid in arriving at a correct diagnosis; on the contrary, it tended to confirm the presence of pneumothorax suggested by the roentgenogram. Lipiodol instillation might have been of value, for it would have shown the defects in the bronchial tree and would have collected "en masse" on the floor of the excavation. On the other hand, if the pathological picture were that of a tuberculous pneumothorax with bronchopleural fistula (a condition which was strongly suspected), the lipiodol would have passed through the fistula and settled on the floor of the pneumothorax cavity. Bronchoscopic examination would have been of distinct diagnostic value; however, the patient was too ill for such manipulation. Aspiration of the air-containing cavity would have been another possible aid in differential diagnosis. This would have been of value if the condition were that of closed pneumothorax. However, it could not have differentiated a giant cavity from a pneumothorax with bronchopleural fistula. It is interesting to note what little healthy pulmonary tissue is necessary to be compatible with life. Another interesting observation, which was mentioned previously, is that the patient had no hemoptysis or even blood-tinged sputum throughout the course of the disease.

In the second case, bronchoscopy with lipiodol instillation would have been of diagnostic value for the reason that a bronchial tree could have been demonstrated within the wall of the emphysematous sac. A view of the roentgenogram in retrospect does cast some doubt on the diagnosis, because there is no distinct demarcation between the area of decreased density and the pulmonary tissue. If the

* A more detailed pathological presentation of this case, with a discussion of etiology, is being reported at greater length in another publication.

diagnosis had been doubted, roentgenograms taken in lateral and oblique positions might have been of diagnostic value.

CONCLUSION

It is apparent from the report of these two cases that history, physical examination and the usual roentgenogram failed to establish a diagnosis. From the pathological evidence it would seem reasonable to conclude that bronchoscopy with lipiodol instillation would have been of diagnostic aid. It is suggested, therefore, that bronchoscopy and lipiodol instillation be used as a routine measure in doubtful cases of pneumothorax.

A ROENTGEN STUDY OF THE CHEST IN TWO HUNDRED PATIENTS WITH GOITER*

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WITH modern skill in the treatment of thyroid disease few patients come to autopsy. The information found at necropsy gives valuable information, but does not necessarily present a true picture of the conditions in those patients who recover. For example, there is a rather widely held opinion that toxins from the diseased thyroid exert a specific effect upon the heart causing the profound cardiac disturbance which these patients show. This view is based upon numerous necropsy reports and in spite of the fact that there are numerous other reports to the effect that no such changes are found. In diseases such as goiter, where most of the patients recover, it is necessary to make use of various indirect means of discovering pathological change. While it is readily admitted that the roentgen ray does not reveal all the knowledge about heart damage, it does give an accurate idea of the cardiac size and shape, as well as evidence of other intrathoracic disease, and hence is a worthy method of examination. The fact that so many of the patients who do die, apparently die cardiac deaths, makes any information that we may be able to obtain valuable.

This study of 200 consecutive patients with goiter was undertaken with three objects in mind: to ascertain changes in heart size and shape, to determine the frequency of substernal thyroid, and to discover other pathological change within the chest. The examination in each instance consisted of a stereoscopic pair of films of the chest made at a moderately deep inspiration, the patient standing, the rays penetrating the chest in a posteroanterior direction from a target film distance of 6 feet.

CARDIAC ENLARGEMENT

A recent paper by McEachern and Rake[6] gives an excellent review of the literature on the pathological findings in the hearts of goiter patients and also a careful study of the hearts of 27 patients dying from hyperthyroidism. Their conclusions are representative of the latest knowledge from the standpoint of the pathologist, namely, that cardiac hypertrophy may result from hyperthyroidism, no adequate correlation can be made between the clinical symptoms and the pathological changes found, no characteristic cardiac changes are found, and that there is no relation between the duration of the hyperthyroidism and the amount of cardiac change. They found that a high percentage of the patients showing marked cardiac damage had organic heart disease definitely not the result of thyrotoxicosis. Lahey[5] states that thyroidism itself does not cause organic heart disease. Reports of roentgen examinations in the literature are scarce; only one was found. Meyer-Borstel[7] examined 76 cases of non-toxic and 80 cases of toxic goiter. He found 59 per cent of the non-toxic and 83 per cent of the toxic had evidence of disturbance in the size and form of the heart. He found a typical form of the thyroid heart, resembling that of mitral stenosis; prominent right border, accentuation of the pulmonary and left median arc, and a steep left border.

In estimating the size of the hearts in this series, use was made of the cardiothoracic ratio advocated by Danzer.[1] No heart was regarded as being larger than normal whose transverse diameter was equal to or less than 52 per cent of the thoracic width.

Of the 200 patients examined, 164, or

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82 per cent, had heart shadows of normal size and 36, or 18 per cent, were larger than normal. Seventeen of the patients had cardiothoracic indices increased less than 5 per cent; 12 between 5 and 10 per cent and 7 above 10 per cent. In presenting these figures it is recognized that a normal cardiothoracic ratio does not definitely rule out cardiac hypertrophy. However, two clinical facts tend to confirm the opinion that these hearts are not hypertrophied: namely, electrocardiograms indicate normal hearts, and after removal of the thyroid the cardiac symptoms, in all but rare instances, disappear.

Because of the present lack of clear correlation between the clinical and pathological findings, difficulties are met with in attempting to group these patients according to the types of diseased thyroids. For purposes of simplicity they have been grouped into two large classes: those with elevated basal metabolic rates, and those with normal or lower than normal basal metabolisms. Sixty-nine, or 35 per cent, had normal basal metabolic rates and, 131, or 65 per cent, elevated basal metabolic rates.

Fig. 1. Cardiac outline resembling mitral stenosis. Sometimes seen in hyperthyroidism.

Fig. 2. Small substernal thyroid.

The group of patients showing normal cardiothoracic ratios were divided as follows: 60 per cent elevated basal and metabolic rates and 40 per cent normal basal metabolic rates, 56.6 per cent of the high basal metabolisms had a pathological diagnosis of hyperplastic thyroid; 20 per cent of these patients were under thirty years of age; 58 per cent between thirty and fifty; 22 per cent above fifty years of age. The average age was forty.

Of the 36 patients showing enlarged hearts, 4, or 11 per cent, had normal metabolic rates and 32, or 89 per cent, elevated rates. Eleven, or 30 per cent, had a histological diagnosis of hyperplastic thyroid. The percentage of elevated metabolic rates is considerably higher in this group than in those with normal hearts—89 per cent as compared with 60 per cent. The percentage of hyperplastic thyroids is materially lower—11 per cent as compared with 56 per cent. Twenty-one, or 58 per cent, had

FIG. 3. Calcification in left lobe of thyroid.

toxic adenomata whereas only 25 per cent of the normal-sized hearts had toxic adenomata. Putting these figures in another way, 49 per cent of the toxic adenomata had enlarged hearts and 20 per cent of the hyperplastic had enlarged hearts.

These patients were older than those in the normal group. None were under thirty; 15 were between thirty and fifty; and 14 above fifty years of age. The average age was forty-eight; eight years older than the group showing average-sized hearts.

I have found attempts to relate the heart size and the duration of the goiter unsatisfactory. A large number of the patients are very vague about the time of the first appearance of the goiter or the symptoms of hyperthyroidism. A large number of the patients with enlarged hearts had had their goiters for a long period of time, that is, over ten years.

A glance at the fatal cases in this series reveals some interesting things. Ten of the patients died; 2 of these had hearts that were of normal size and shape on the roentgenogram. Unfortunately, they did not come to necropsy. One of them died of pulmonary embolism; no cause was apparent for the other death. The remaining 8 were all examined after death and the finding of enlarged heart on the roentgenogram confirmed. Six of the 8 showed hearts of approximately 50 per cent larger than normal, by weight. The cardiac findings at autopsy in these patients are as follows: 2 showed healed pericarditis, 2 vegetative endocarditis, one infectious endocarditis, one mitral stenosis, 2 hypertrophy with chronic myocarditis and one of these had a hypertrophied thymus. The hypertrophy of the thymus could not be recognized on the film.

From the foregoing figures it is apparent that cardiac enlargement is not particularly common in thyroid disease. The older patients have a greater tendency to cardiac enlargement, but no relation could be elicited between duration of the thyroid and the cardiac enlargement. The autopsy findings of so many diseases of the heart, that are quite definitely not associated with goiter, indicate that a large number of the patients with hypertrophy have it as a result of the heart disease, irrespective of their thyroid disease. The ages of the patients who have cardiac hypertrophy tend to support this view, as such a large majority of them were in the age group where cardiac disease is common.

These hearts were examined particularly with regard to shape. Thirteen of the hyperplastic types had hearts similar in outline to those described by Meyer-Borstel. Four patients with toxic adenomata showed the same shape. There were certainly not enough hearts in this series showing characteristic shapes to indicate that thyroid disease is reflected in the cardiac outline.

SUBSTERNAL THYROID

There is some opportunity for confusion in using the term "substernal." Several classifications have been suggested which are essentially the same, though varying in elaborateness and terminology. Judd[3] sug-

gested using the term "intrathoracic" when the greater part of the goiter was in the thorax and "substernal" when only a portion projected into the chest. This terminology will be used in this paper.

There is considerable variation in the percentages of substernal and intrathoracic goiter given in the literature. Higgins[2] gives the intrathoracic type as being present in 1–2 per cent and the substernal in 10 per cent. Judd[3] found 5 per cent intrathoracic and 50 per cent substernal.

One patient only in this group showed an intrathoracic goiter, an incidence of 0.5 per cent. Twenty-seven patients had substernal goiters, or 13.5 per cent; 23 of these were identified preoperatively on the films, but in 4 no suggestion of substernal projection on the films which was found at operation. It is possible that these slight discrepancies between film appearance and operative findings are to be accounted for by an abnormal movability of the thyroid, the respiratory acts causing it to move in and out of the chest to a slight extent. Lahey[4] reports seeing such movement at roentgenoscopic examination.

INCIDENTAL FINDINGS

The coincidental findings in the chests of these patients were not impressive by their frequency. Nine had tuberculous infiltrations, one had a lung abscess, one mediastinal metastasis from carcinoma of the breast, 2 had chronic lower lobe infection, and 2 had pleural effusions.

Calcification of the thyroid was seen on the films only 4 times, while it was found on pathological examination of the removed specimens in 13 instances. With one exception these areas of calcification were small, averaging under 1 cm. in diameter. One patient showed a large nodule about 3 cm. in diameter which was rather densely calcified.

SUMMARY

Stereoscopic teleroentgenograms of 200 patients suffering with goiter were made.

Thirty-five per cent of the patients had normal or lower than normal basal metabolic rates and 65 per cent had elevated basal metabolic rates.

Eighteen per cent had heart shadows larger than normal.

Eighty-nine per cent of the patients with enlarged hearts had elevated basal metabolic rates and 60 per cent of those with normal-sized hearts had elevated metabolic rates.

Eighty per cent of the patients who succumbed had enlarged hearts and showed evidence of true organic disease of the heart at post mortem.

Patients who were suffering from goiters, which are at present included under the term toxic adenoma, showed a much greater tendency toward cardiac hypertrophy, 49 per cent, than those classed as hyperplastic thyroids, 20 per cent.

There is no characteristic heart shape in thyroid disease.

Thirteen and five-tenths per cent had partially substernal thyroids, and 0.5 per cent had true intrathoracic goiters.

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THE SUPERIOR VALUE OF THE EXPIRATORY ROENTGENOGRAM IN THE DIAGNOSIS OF INCOMPLETE PNEUMOTHORAX*

By SIDNEY GREENBERG, M.D.
RAY BROOK, NEW YORK

SMALL pneumothoraces may escape detection by the physical examination or even by the roentgen examination when the exposure is made at the height of inspiration. In such instances a roentgenogram taken at the end of forced expiration may often reveal the condition. The superiority of the expiratory film may be attributed to the fact that the volume of the pneumothorax remains practically constant during respiration while the surface area of the pleural sac is altered, being increased on inspiration and decreased on expiration. These variations in the surface area of the pleural sac incident to respiration produce a definite change in the distribution of the pneumothorax. The roentgenogram reveals that the layer of air about the lung becomes alternately thinner on inspiration and thicker on expiration. The shadow cast by the thin layer of air on inspiration may be completely obscured by the shadow of the lateral chest wall; whereas the relatively thicker layer of air on expiration is readily seen. The greater thickness of the layer of air and the contrast offered by the increased density of the shadow of the lung on expiration account for the superiority of the expiratory film in the detection of small pneumothoraces.

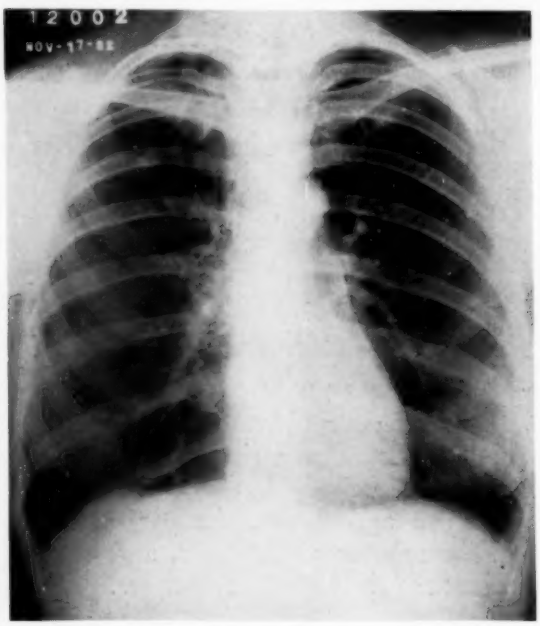

FIG. 1. Inspiratory roentgenogram taken immediately after the initial introduction of 100 c.c. of air into the right pleural cavity. Pneumothorax not visible.

Figures 1 and 2 represent roentgen exposures made at the height of inspiration and at the end of forced expiration, following an initial introduction of 100 c.c.

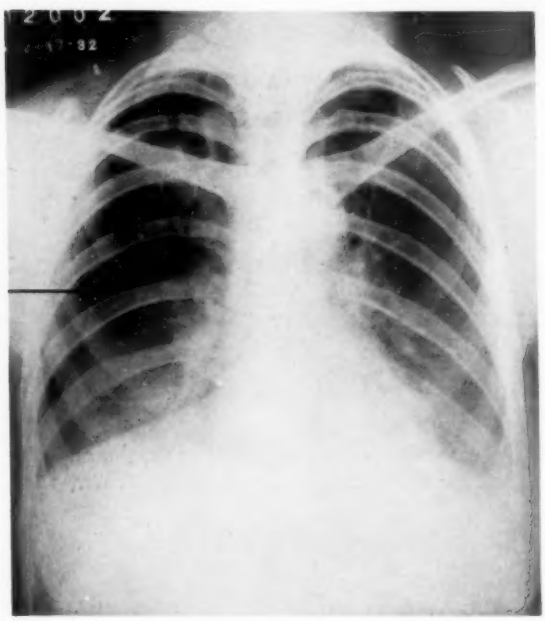

FIG. 2. Same case as Figure 1. Expiratory film taken immediately after Figure 1. Pneumothorax now visible on right side.

* From the New York State Hospital for the Treatment of Incipient Pulmonary Tuberculosis.

Fig. 3. Inspiratory roentgenogram (enlargement of Figure 1). Pneumothorax not visible.

Fig. 4. Expiratory roentgenogram (enlargement of Figure 2). Pneumothorax evident.

of air into the right pleural cavity. The shadow of the pneumothorax is seen only on the latter, best illustrated in the enlargement of the roentgenograms (Figs. 3 and 4). This also holds true for Figure 5

Fig. 5. Inspiratory roentgenogram taken immediately after the initial introduction of 200 c.c. of air into the right pleural cavity. Pneumothorax not visible.

Fig. 6. Same case as Figure 5. Expiratory film taken immediately after Figure 5. Pneumothorax now visible on right side.

Fig. 7. Inspiratory roentgenogram (enlargement of Figure 5). Pneumothorax not visible.

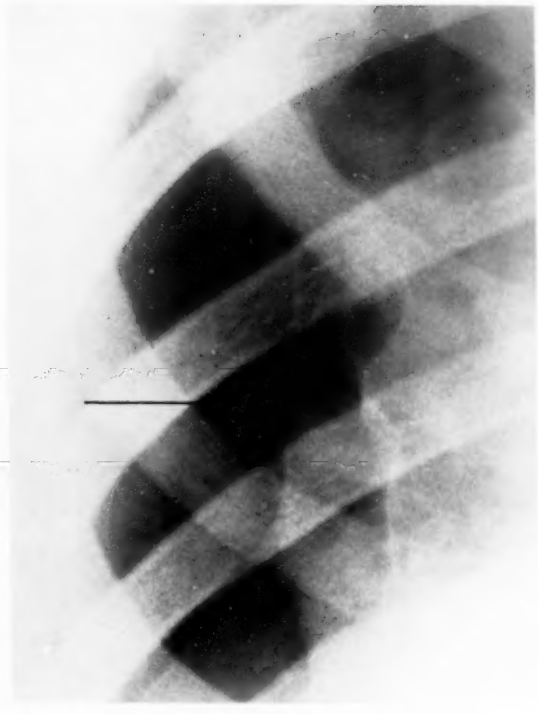

Fig. 8. Expiratory roentgenogram (enlargement of Figure 6). Pneumothorax evident.

(inspiratory) and Figure 6 (expiratory) following the introduction of 200 c.c. of air into the right pleural cavity. Figures 7 and 8 represent enlargements.

These observations indicate the value of the expiratory roentgenogram in the diagnosis of small pneumothoraces. The study of the inspiratory and expiratory film may also be utilized in measuring the degree of inflation and deflation of the diseased and healthy parts of the lung in treatment by artificial pneumothorax.

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THE SYMPHYSIS PUBIS IN THE FEMALE*

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WITHIN recent years a rather extensive literature has developed about the female pelvis and roentgenological methods for determining its size. In spite of the number of technical and mathematical procedures described, this material is strangely silent regarding some fundamental anatomical and physiological considerations. This neglect seems rather unusual because the pelvis, of all skeletal parts, presents an easily demonstrated and very sensitive indicator of its behavior: the symphysis pubis. As has been shown by Chamberlain,[1] the symphysis pubis clearly reflects sacroiliac changes, such as increased mobility and rotation.

The older clinicians took advantage of the information furnished by examination of this joint and from time to time rejuvenation of the ancient theory of pelvic relaxation during pregnancy has redirected attention to this important structure. However, while many articles have been written concerning the behavior of this joint and the sacroiliacs during pregnancy and parturition, much that is controversial, not only as regards its function but even its different anatomical phases, still remains.

Viewpoints accepted years ago and for a period entirely discarded are returning and it becomes increasingly apparent that a more thorough study of the joint promises rich rewards not only in obstetrics, particularly pelvimetry, but in orthopedics and endocrinology as well.

The investigations to be reported at this time arose primarily from an interest in the notchings and irregularities of the faces of the pubic bones. These were encountered from time to time and bore a striking resemblance to the changes produced in the spinal segments by nucleus pulposus invasions. For a time autopsy material was searched in an attempt to clearly explain the findings. However, the paucity of suitable material and the rather constant limitation of the changes to females eventually led to a systematic investigation of the female symphysis pubis.

Since starting this study several somewhat similar ones have come to light, many of which antedate the roentgen period. In addition, much relatively recent anatomical work offers sound explanation for the varying appearances of the symphysis in different individuals. The results of the present study are therefore presented not only to increase the amount of material pertaining to the behavior of the symphysis, but also with a view to correlating the anatomical findings with the roentgenological appearances of the joint.

ANATOMY

Piersol[2] describes the symphysis pubis as a typical half joint, the fibrocartilage coating the opposed pubic surfaces being very dense and the central cavity or cleft being small and lying nearer the back than the front. The total breadth of the soft parts rarely exceeds 5 mm.

The cartilages are ensheathed in fibres, the deeper parts of which are inseparable from them, those above and behind are of little consequence. The anterior ones are in several layers being in part composed of fibres from the aponeurosis of the external oblique and fibres of origin of the rectus. They are in the main transverse but those from the obliques run downward and inward sometimes making a distinct decussation. The inferior or subpubic fibres are collected into a dense transverse band.

Spalteholz[3] in describing the joint points out that a fibrocartilaginous disc lies between the hyaline cartilage covered bone ends. This projects as a narrow ridge on the posterior surface while in front it broadens and is intimately connected with

* From the Millard Fillmore Hospital, Buffalo, N.Y. Read at the American Congress of Radiology, Chicago, Ill., Sept. 25–30, 1933.

the deeper fibers of the anterior ligament. The deeper fibers of the inferior or arcuate ligament are also intimately connected with the fibrocartilaginous disc. Within the interarticular disc a small slit is commonly present. This lies posteriorly and extends almost over the upper half of the fibrocartilaginous mass. This joint slit is larger in the male than in the female.

The origin of this joint space or fissure has been and remains a somewhat controversial subject.

Fick,[4] reporting observations on 107 symphyses, states that of 18 fetal or newborn specimens the joint cavity was absent 5 times and in 30 symphyses obtained during the first year of life it was absent 13 times. However, in 59 specimens obtained at the ages of from two to seventy-five years, the cavity was absent only once. The largest fissure was found in a thirty-two year old multipara, and he notes that the largest cavities found in male symphyses are smaller than the smallest found in females.

Loeschcke,[5] after reviewing the current anatomical concepts, describes his own dissections in which he never observed genuine fissure formation in children. A transverse section of the symphysis in early childhood shows the bony substance of the two pubic rami covered with a wide layer of hyaline cartilage. A typical growth zone is noted at the junction with the primitive cartilage. The cartilaginous ends are placed diagonally in such a manner that they diverge anteriorly and approach each other internally or posteriorly. An interarticular disc is present between the layers of hyaline cartilage. This is distinct from the hyaline layers having a more fibrous basic structure and larger cell groups. The interarticular disc receives its blood supply through arterial twigs which penetrate it from the strong anterior ligament of the joint and to a lesser degree from the weaker posterior ligament. The small interarticular disc in young children grows more rapidly than other parts of the symphysis and at puberty constitutes one-half to two-thirds of the sagittal diameter of the joint. At this time it constitutes an oval disc which occupies the inner surface of the symphysis lying somewhat posteriorly and being surrounded superiorly and inferiorly by a stratum of connective tissue related to the external capsule. The disc is composed of concentric laminations of fibrocartilage. During development the bone ends are growing at the expense of the hyaline cartilage. The irregularity of this growth results in notching or serration of the advancing border. An isolated secondary ossification center is often found in the cartilage in the superior outer part of the joint.

This bone growth continues usually to the age of twenty-four to twenty-five, at which time the zones of hyaline cartilage have become narrower, the demarcation between cartilage and bone is more straight edged and sharply outlined and the anterior divergence of the pubic faces has disappeared.

According to Loeschcke, fissure formations in the interarticular disc appear at the conclusion of the growth process. These fissures appear first between the laminations but later small areas of degeneration of the fibrocartilage and vessels themselves become confluent and form the space within the disc. The degenerations he attributed to the trauma of weight bearing.

Putschar,[6] on the other hand, found a median symphysis fissure indicated in the first years of life. He found vascularization and degeneration of the hyaline cartilage during the growth period and attributes the changes observed to the continual trauma of walking. In older individuals he finds fissure formation located in the central portion of the disc superiorly which bends sharply off inferiorly to course along one side of the border between the fibrous and hyaline cartilage, often extending down to the arcuate ligament. If the space between the hyaline and fibrous cartilage has been subjected to trauma, irregularities in the hyaline cartilage develop. In some places the latter is entirely absent, in

which case pannus-like fibrous areas border directly on the cleavage space.

Eymer and Lang[7] agree with Putschar in feeling that the fissure appears early in life as the result of a functional claim, the increased load of walking.

The investigations regarding the formation of the pubic joint space at first appear rather academic. However, the behavior of different symphyses under varying conditions is by no means stereotyped and it is quite possible that these discrepancies in anatomical findings may be related to the variable behavior of different joints under identical conditions.

FUNCTION

Mechanically the symphysis serves to anchor the ends of the two weight-bearing arches of the pelvis, the femorosacral and the ischiosacral arches. Under normal conditions it is exceedingly resistant to separation. De Lee[8] estimates the force required to disrupt the pelvic girdle as between 400 and 2,600 pounds, while Düntzer[9] quotes Fessler's investigation showing that a pressure of 170–280 kilograms is necessary to rupture the human symphysis.

These estimates of strength receive some support from clinical observations of the behavior of the joint in the presence of pelvic fractures.

In an analysis of 34 cases of fracture in which the force was transmitted through both the anterior and posterior aspects of the pelvic ring, demonstrable separation of the symphysis pubis occurred but twice. In both instances the separation occurred in women of child-bearing age and was associated with multiple fractures of both sides of the pelvic girdle.

With proper direction of force, however, symphyseal separation may be produced. Timm,[10] in reporting 2 cases of subluxation of the symphysis pubis and sacroiliacs unassociated with fracture, calls attention to the unusual nature of the accident. He quotes the experiments of Areilza who was able to effect a luxation of the symphysis with or without sacroiliac involvement. The isolated symphyseal luxation could be effected by a strong pull of the adductors or by a wedge-like force between the pubic bones. The first of these mechanisms has been of sufficient frequency in equestrians to become known as "rider's luxation."

The second mechanism comes into play during childbirth and appears to be an important factor in the production of rupture of the symphysis during labor. Reis, Baer, Arens and Stewart,[11] in an excellent review of the literature pertaining to symphyseal rupture during spontaneous labor, call attention to the various hypotheses advanced to explain its occurrence. They agree with Keller's explanation that symphyseal rupture in spontaneous labor is due to marked intensity of the uterine contractions plus marked rapidity of labor.

This conclusion does not completely explain the disproportion existing between the incidence of vigorous labor and symphyseal rupture. As they point out, the total force exerted by uterine and abdominal contraction is only one-quarter the amount required to produce experimental symphyseal rupture. It is quite likely that position during delivery, particularly the extreme abduction of the thighs, aids in producing symphyseal rupture through traction on the adductors. However, this position is quite commonly used whereas rupture occurs in but 1 in 5,000 to 1 in 30,000 deliveries.

It would seem that other factors, particularly the anatomical condition of the symphysis, should be considered in the etiology of rupture.

It has been known since the time of Hippocrates that definite changes occur in the pelvic ligaments during pregnancy which allow an increased mobility and varying degrees of widening of the joints.

Jarcho,[12] in a recent monograph, gives an excellent summary of the earlier literature on this subject, but in the chapter dealing with repudiation of pelvic bone separation theory he says:

> So long as the theory of pelvic bone separation during delivery was maintained, the scientific

development of pelvimetry was hopelessly retarded. According to this theory the fixed measurements of the pelvis were considered of slight importance. Attention was focused on the fancied ability of the pelvis to stretch for the passage of the fetus. Never demonstrated by any observation that could be considered scientific evidence, this theory stands as an example of false tradition handed down century after century by masters whose authority was never questioned.

Jarcho's conclusions on the question of pelvic relaxation during pregnancy are supported by the investigations of Reis and his coworkers. They examined 80 pregnant women at six to eight week intervals from the second or third month of pregnancy up to the time of delivery and again ten days post partum. In discussing their results they say:

It has been impossible to find any characteristic changes in the symphysis pubis during pregnancy. Multiparity apparently has no effect on the joint that can be demonstrated roentgenologically. Nor has it been possible to demonstrate any change in the joint during pregnancy or the puerperium. Repeated films taken at varying intervals throughout pregnancy as well as post partum show no changes in the symphysis pubis. In no instances in this series of 80 patients followed through the course of their pregnancy was any change found.

These findings are quite at variance with numerous observations in the literature. For instance De Lee says:

The pelvic girdle is affected by the changes of pregnancy. The author has determined an actual increase of the size of the pelvic cavity. Measurements taken of contracted pelves before conception and just before labor will often show this and women in whom labor was predicted as impossible may have spontaneous or easy operative deliveries. . . . In women an actual enlargement of the pelvis in labor occurs only in very slight degrees but the softening of the joints allows free motion of the bones and thus a certain configuration which facilitates delivery.

Baetjer and Waters[13] call attention to the frequency of symphysis pubis separation in women after childbirth. Many other authors have called attention to this relaxation of pregnancy. More prominent and convincing among this group may be mentioned Snelling,[14] Driver,[15] Cantin,[16] Goldthwait and Osgood,[17] Brehm and Weirauk,[18] Müller,[19] Martius,[20] Putschar, Loeschcke, Eymer and Lang, Heyman and Lundqvist[21] and recently Abramson, Roberts and Wilson.[22] The incidence and degree of relaxation varies somewhat in the different reports and the accuracy with the method of measuring. The reports of Snelling, Driver and Cantin based on clinical findings indicate the presence of minor degrees of relaxation in the majority of pregnant women. They regarded these changes as physiological as long as no clinical symptoms such as disturbed gait or pelvic pain occurred.

Those authors using the roentgen method of measurement are more definite in their statements. Brehm and Weirauk in a study of 54 cases before and after delivery found no separation of the symphysis in 25 cases, slight separation, 0.5–0.9 cm., in 15 cases, moderate separation, 0.9–2 cm., in 13 cases and in one case a separation of more than 2 cm. They found that separations of more than 1 cm. were associated with symptoms.

Müller examined a series of 100 cases. These were roentgenographed before delivery and again a day or so after labor. He considered slight separation as normal and found decided separations to be quite frequent. He cautions that these separations may be mistaken for ruptures of the symphysis unless the clinical symptoms are taken into consideration. True ruptures are always associated with intense pubic pain and swelling. In addition the patient may be unable to move her legs, a pseudoparalysis. These clinical manifestations of rupture may or may not be associated with demonstrable pubic widening. In other words, the diagnosis of rupture depends on clinical rather than on roentgen findings.

Heyman and Lundqvist, in examining 74 pregnant women, noted an increase in the width of the symphysis of from 1–4

mm. The greatest increase observed in their series occurred between the fifth and seventh months. They felt that no increase occurred during the last two months or during delivery. Wilson and his coworkers examined 111 women in the last two months of pregnancy and found an average symphyseal width of 7.7 mm. The maximum width in this group was 20 mm., the minimum 3 mm. Most of the women in this group were multiparas and 24 per cent showed a width of 9 mm. or more.

In 25 primaparas examined during the last two months they found an average symphyseal width of 7.9 mm.; 28 per cent of these measured 9 mm. or more.

From these findings they felt that no essential difference existed between primiparas and multiparas.

They furthermore conducted comparative studies on 15 individuals before and within a few days after delivery. In these they found the width of the symphysis increased in 9, stationary in one and diminished in 5.

From pure force of numbers and constancy of observation it would appear that the earlier writers from Hippocrates on were correct in their observation of pelvic relaxation and that those failing to observe evidences of this change during pregnancy have either accidentally happened on a run of case material which did not demonstrate it or have been hindered by faulty observations.

It may then be assumed that evidence of pelvic relaxation occurs during pregnancy and that the importance of this relaxation depends on the frequency and extent of its occurrence.

PRESENT STUDY

In the present study five groups of case material were studied. The first four groups were collected chiefly to serve as control material and as a basis of comparison for the fifth group.

(1) Autopsy material consisting of 19 symphyses taken from male and female bodies and 8 symphyses of new-born babies. Removal from the bodies was accomplished by means of a saw and bone clippers in the adults and scissors in infants.

(2) Developmental material consisting of 20 cases of boys and girls from two to fourteen years of age and in addition 30 cases of young unmarried women examined during the epiphyseal or late developmental period of from seventeen to twenty-three years.

(3) Non-pregnant adult females consisting of 140 cases varying from twenty-four to seventy years of age.

(4) Males: 130 adult cases ranging from twenty-five to seventy years of age.

(5) Pregnant females: This group consisted of 180 cases. Of these 99 were multiparas and 81 were primiparas. The following distribution of cases occurred in the various decades:

Second	7 cases
Third	94 cases
Fourth	70 cases
Fifth	9 cases

In the autopsy material the removed symphyses were roentgenographed on plain films with a 30 inch target-film distance.

In the second group the 30° posteroanterior projection for detail of the pubis was used and in the third and fourth groups films of the abdomen and pelvis were utilized to establish a norm. A 30 inch target-film distance was used throughout. It is realized that the distortion which occurs in anteroposterior projections might lead to variances if compared directly with films taken in posteroanterior or oblique projections. A study of the amount of this distortion conducted on autopsy material proved an accuracy throughout of ± 1 mm. and since in some of the developmental and pregnancy cases, points for measurement could not be localized with any greater accuracy, these limits are accepted for the error in measuring.

In the pregnancy group several projections were used. At the beginning of the work most of the films were taken in the semi-sitting position commonly used for measurement of the pelvic inlet. Later the detail pubic projection was added and in the most recent cases this detail projection has been used exclusively. All of the films

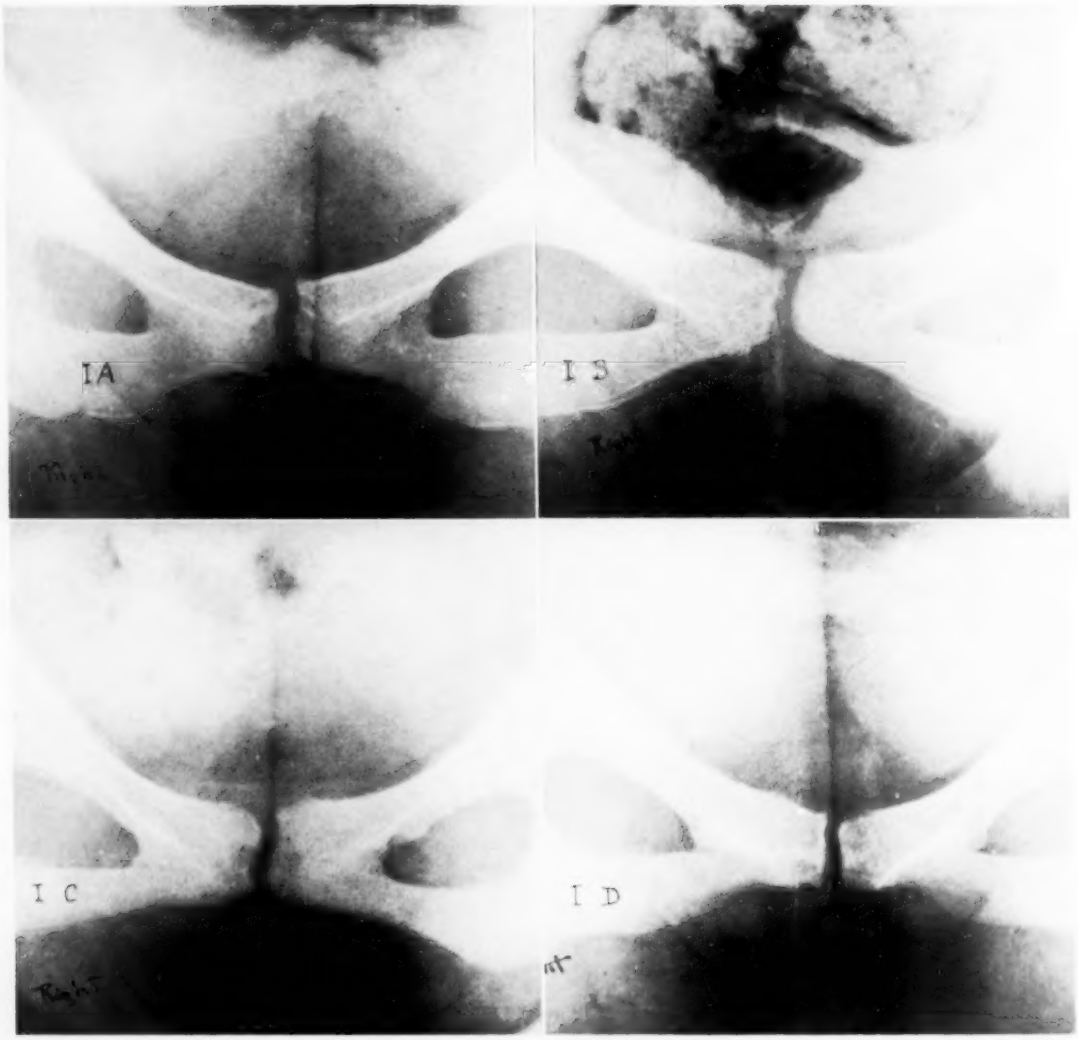


FIG. 1. Symphyses in non-pregnant young women. A. Seventeen years old. The pubic faces show the serration of the late developmental or epiphyseal period. Left pubic ramus 2 mm. higher than the right. Left asymmetry. Slight fringing of the superior margin on left. B. Nineteen years old. Curved type of symphysis showing serration. C. Nineteen years old. S-type of symphysis. The pubic faces are becoming smooth. D. Twenty-three years old. The pubic faces show completion of their cortical ossification. Slight fringing of superior left margin.

TABLE I

Autopsy Material			Males	Non-Pregnant Females		Developmental
	Adults	Infants		Adult	Epiphyseal	
Width	Average 3.8 mm.	5.4 mm.	4.2 mm.	4.0 mm.	5.5 mm.	5.5 mm.
	Extremes 2.5–4 mm.	5–6.5 mm.	3.5–5 mm.	2.5–5 mm.	5–6.5 mm.	5–6.5 mm.
Difference in level of pubic rami, asymmetry	None	None	14% with an average of 0.8 mm.	44%–1 mm. or more 20%—2 mm. or more	30%—1 mm. or more 13%—2 mm. or more	None

were examined particularly for the following points: (1) state of skeletal development; (2) width and configuration of the symphysis, and (3) symmetry of the pubic rami, particularly regarding differences in level.

A summary of these observations on the control groups is presented in Table 1.

In measuring the width of the symphysis it is quite important to differentiate between the adult and various developmental types. At birth the soft tissue between the rounded ends of the two pubic bones measures from 5–6.5 mm., with an average of 5.4 mm. This width of soft tissue remains fairly constant through the preadolescent period and the bone ends maintain their smooth, rounded configuration. In none of these cases was asymmetry, fringing or alteration in the osseous structure noted. At or shortly after puberty the rounded contour of the pubic faces begins to show irregularities and serrations and at the same time the rounded borders show a tendency toward squaring. These changes become more marked in the age periods of from sixteen to twenty-one years. During this latter period accessory ossification centers may rarely be noted within the cartilage. The ragged, serrated border of bone development which is at times quite hazy gradually becomes more clearly defined; the irregularities in contour become less marked; the rounded superior and inferior angles fill in, becoming squared and the final phase of pubic development is completed at about the ages of twenty-three to twenty-five. During this period the average soft tissue measurement in both sexes is 5.5 mm. and measurements up to 6 or 6.5 mm. are not uncommon. Hence, unless the developmental characteristics are looked for, an erroneous diagnosis of widening may be made in these cases.

Irregularities of bone growth during the final or epiphyseal stage lead to variations in the final appearance of the symphysis. Thus we have the V-shaped, S-shaped or irregularly notched pubic faces.

A cessation of bone growth in one area results in a residual, rarefied island or notch in the pubic face. According to Lang and Haslhofer,[23] these islands result from small areas of liquefaction and mucoid degeneration of the ground substance of the cartilage.

In measuring the differences in pubic level care was taken to avoid being misled by unequal development of hypertrophic spurs on the superior margin of the symphysis. In addition to the three main considerations, an attempt was made to classify the character of the osseous structure in the pubic margins and to estimate the degree of ligamentous calcification present. The appearance of the osseous structure varies considerably at different ages. Thus the hazy, ill-defined pubic faces of the epiphyseal period gradually change

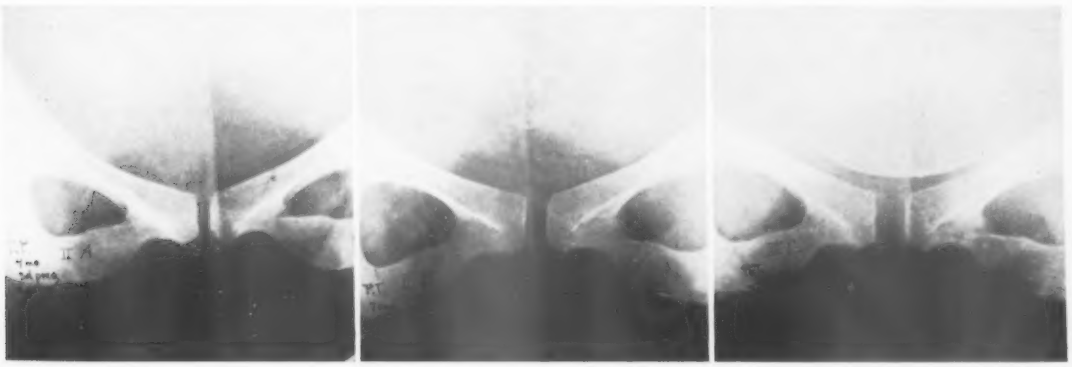
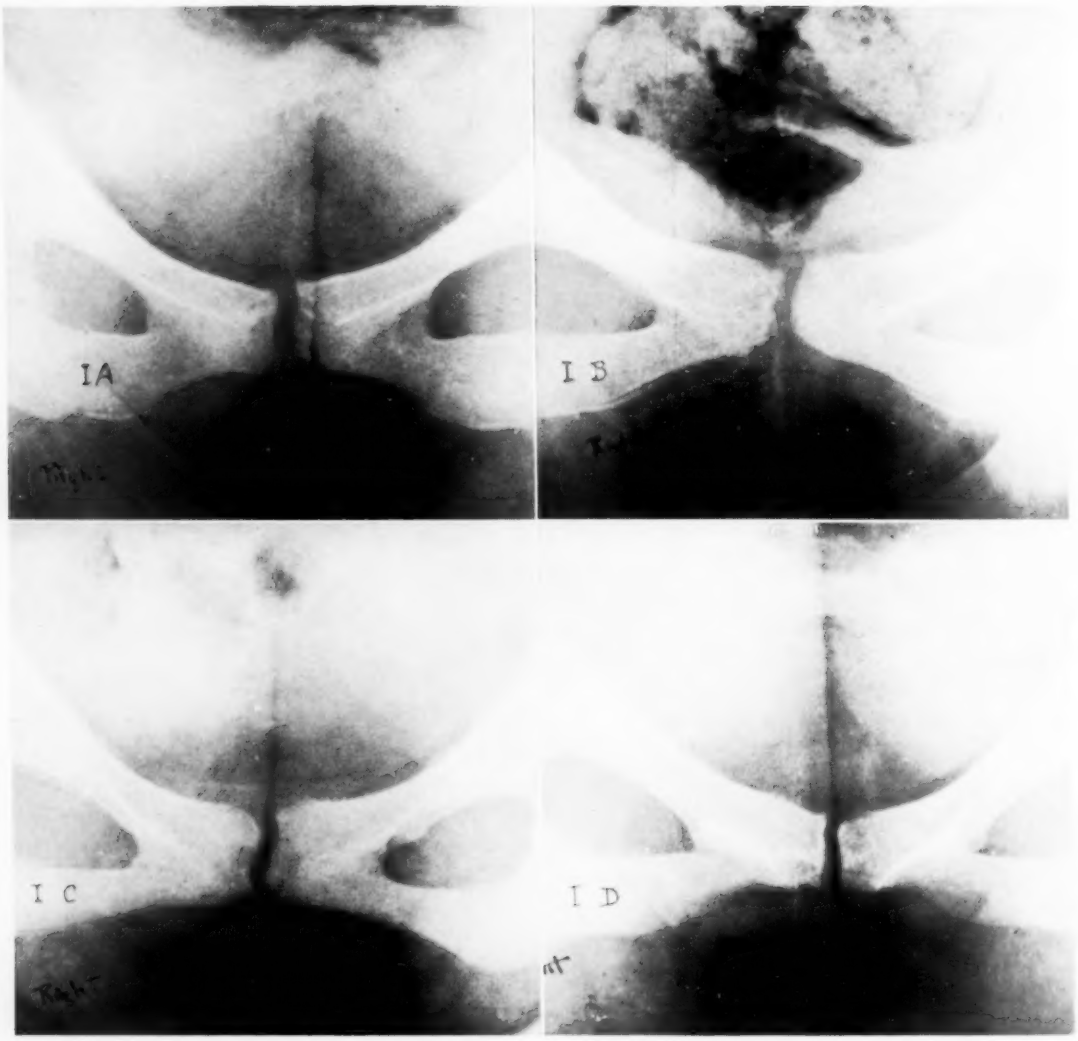


Fig. 2. T. P., aged twenty-eight. Third pregnancy. Repeated examinations on the same patient. A. Film taken at the fourth month. Symphysis symmetrical and measuring 4 mm. B. Seventh month; 7 mm., symmetrical. C. Ninth month; 11 mm., symmetrical.



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In measuring the width of the symphysis it is quite important to differentiate between the adult and various developmental types. At birth the soft tissue between the rounded ends of the two pubic bones measures from 5–6.5 mm., with an average of 5.4 mm. This width of soft tissue remains fairly constant through the preadolescent period and the bone ends maintain their smooth, rounded configuration. In none of these cases was asymmetry, fringing or alteration in the osseous structure noted. At or shortly after puberty the rounded contour of the pubic faces begins to show irregularities and serrations and at the same time the rounded borders show a tendency toward squaring. These changes become more marked in the age periods of from sixteen to twenty-one years. During this latter period accessory ossification centers may rarely be noted within the cartilage. The ragged, serrated border of bone development which is at times quite hazy gradually becomes more clearly defined; the irregularities in contour become less marked; the rounded superior and inferior angles fill in, becoming squared and the final phase of pubic development is completed at about the ages of twenty-three to twenty-five. During this period the average soft tissue measurement in both sexes is 5.5 mm. and measurements up to 6 or 6.5 mm. are not uncommon. Hence, unless the developmental characteristics are looked for, an erroneous diagnosis of widening may be made in these cases.

Irregularities of bone growth during the final or epiphyseal stage lead to variations in the final appearance of the symphysis. Thus we have the V-shaped, S-shaped or irregularly notched pubic faces.

A cessation of bone growth in one area results in a residual, rarefied island or notch in the pubic face. According to Lang and Haslhofer,[23] these islands result from small areas of liquefaction and mucoid degeneration of the ground substance of the cartilage.

In measuring the differences in pubic level care was taken to avoid being misled by unequal development of hypertrophic spurs on the superior margin of the symphysis. In addition to the three main considerations, an attempt was made to classify the character of the osseous structure in the pubic margins and to estimate the degree of ligamentous calcification present. The appearance of the osseous structure varies considerably at different ages. Thus the hazy, ill-defined pubic faces of the epiphyseal period gradually change

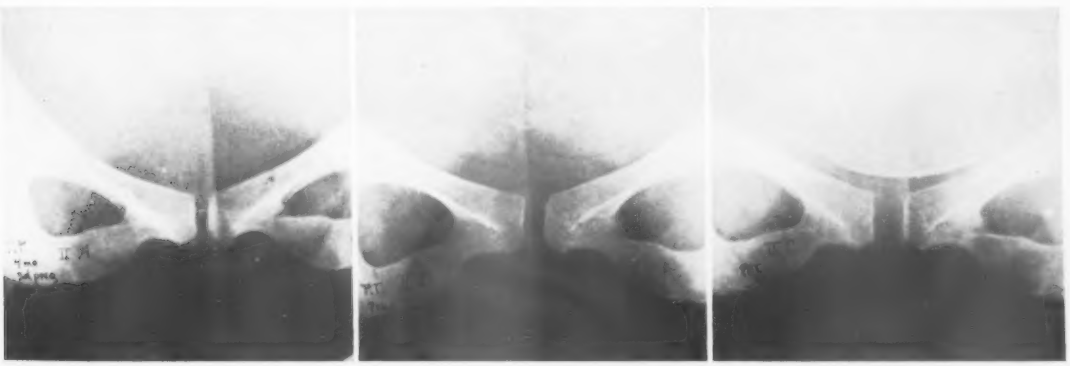

Fig. 2. T. P., aged twenty-eight. Third pregnancy. Repeated examinations on the same patient. A. Film taken at the fourth month. Symphysis symmetrical and measuring 4 mm. B. Seventh month; 7 mm., symmetrical. C. Ninth month; 11 mm., symmetrical.

to the clear-cut, well-calcified cortical margins of adult life, and still later begin to show the mixed rarefaction and sclerosis seen in arthritic changes.

Roughly paralleling the changes of bone architecture are the ligamentous calcifications which manifest themselves roentgenologically as fringing or lipping. These changes vary in such minor degrees that an accurate grouping would be quite difficult.

While the mild arthritic changes, fringing and sclerosis, occur for the most part in adult life, evidences of them may at times be found in the late developmental period. They occur in both sexes but are much more frequent in females than in males.

The significance of this finding will become more apparent after a study of the symphysis during pregnancy.

It will be seen from Table I that the width of the symphysis pubis in adult males and non-pregnant females is practically identical and that a norm of 5 mm. would include any extremes met with. However, the epiphyseal or late growth phases may not be complete until twenty-five years of age, or even later, and since many pregnancies occur during this period it was thought best to take the higher average figure of this group, 5.5 mm., as standard for comparison. This norm agrees within reasonable limits with the anatomical average of Piersol and the roentgenologic average of Markovits.[24]

For study purposes the pregnancy group may be divided into the usual obstetrical trimesters; 40 cases were examined in the first period, 80 cases in the second and 124 cases in the third periods. In addition, 42 cases were examined post partum, most of these within the first two weeks, a few at intervals of two or three months. The results of the measurements taken during pregnancy are shown in Table II. The group examined during the third trimester was divided into primipara and multipara groups with a view to emphasizing the greater degree of relaxation in multiparas.

It is evident from this table that even if we should take the upper limit of developmental width, 6.5 mm., as a normal standard definite evidences of widening occur during pregnancy.

Nearly all of the 40 cases examined during the first trimester measured less than 5 mm. The one case measuring 6 mm. was quite definitely of the developmental type and when re-examined at the seventh and ninth months and again twelve days post partum showed no appreciable change in

TABLE II

WIDTH OF SYMPHYSIS DURING PREGNANCY

Symphysis Measurement in mm.	First Trimester 40 Cases	Second Trimester 80 Cases	Third Trimester 124 Cases	
			Primiparas 52 cases	Multiparas 72 cases
5 mm. or more	12.5%	45%	75%	80%
6 mm. or more	1 case	28%	50%	57%
7 mm. or more	None	11%	21%	42%
8 mm. or more	None	2 cases	4% 2 cases measuring 8 mm.	26%
10 mm. or more	None		4% 2 cases measuring 10 mm.	10%
20 mm. or more	None	1 case measuring 20 mm.	None	4 cases

width. Therefore from the evidence at hand I cannot confirm the opinion of those who feel that relaxation occurs early in pregnancy.

While early pregnancy relaxation may occur in exceptional cases or be demonstrable by a technique such as described by Chamberlain, it would seem that the differentiation from relaxation which may occur during menstruation would be extremely difficult and that a suspicion of pregnancy on the basis of this finding would be unjustifiable.

In this series definite widening first appears about the middle of the second trimester and increases up to the time of delivery.

Our experience with widening during the last two months of pregnancy differs from that of Heyman and Lundquist. In 19 cases upon whom multiple examinations were made during the last trimester, 10 showed increases in width ranging from 1 to 4 mm.

It will be noted that 26 per cent of the multiparas showed symphyseal widening of 8 mm. or more, and that 4 cases showed 20 mm. or more. In none of these cases were any clinical symptoms caused by the widening. It does not follow that symptoms may not occur in such cases. On the contrary, the waddling gait, pelvic instability and symphyseal or sacroiliac pain have been reported repeatedly in connection with severe relaxation.

While group studies of this type are valuable for statistical purposes, multiple observations on one individual are more instructive regarding individual variations.

For this reason a group of 49 cases was studied by means of films taken during the first or second two and again in the last trimester. The degree of symphyseal change may be seen in the following tabulation:

Extent of Widening Occurring Between Examinations	Primiparas 22 cases	Multiparas 27 cases
2 mm. or more	59%	56%
3 mm. or more	18%	37%
4 mm. or more	1 case showed a a 6 mm. change	18%
5 mm. or more		15%
10 mm. or more	None	10%

Here again the difference in degree of widening between primiparas and multiparas is striking.

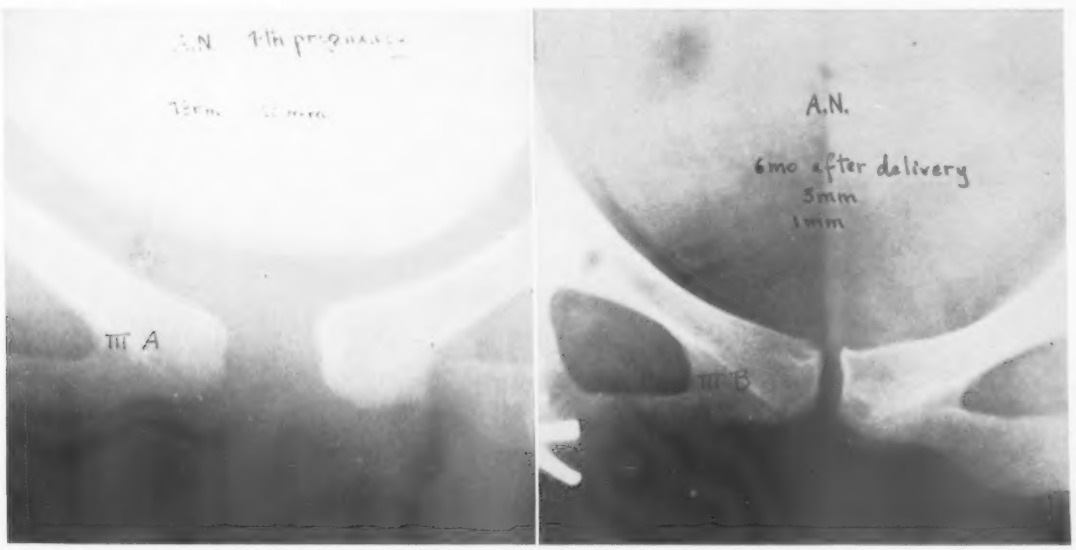

FIG. 3. A. N., aged thirty. Fourth pregnancy. Demonstrating slight reversal of asymmetry. A. Film taken at term, symphysis measures 25 mm., very slight elevation of left ramus. Left asymmetry. B. Film taken six months post partum; symphysis measures 5 mm. with about 1 mm. of right asymmetry.

Post partum examinations reveal a prompt return to normal width of the symphysis. Within the first two weeks a decided narrowing occurs and in those which showed only moderate widening, under 1 cm., restitution may be complete in this time. However, in extreme spreading, 15 mm. or more, a month or so may elapse before the normal width is attained. Cases of more or less permanent widening which eventually required operative repair have been reported, particularly following symphyseal rupture. However, none of the cases studied in this group showed any tendency to residual widening and in none was any orthopedic appliance other than the usual post partum pelvic binder applied. Table III shows the results of measurements on post partum cases. The greatest recorded width is included for comparison. In some instances the greatest recorded width probably does not represent the greatest width attained since some of the pre-delivery films were taken during the eighth or early part of the ninth month. This return to normal within a short time is even more striking than the widening during pregnancy, particularly in view of the relaxed condition of the ligaments and musculature following delivery.

In addition to width measurements, the pregnancy group was also examined for evidence of asymmetrical pubic rami, changes in the structure of the pubic faces and evidences of calcification in the ligaments. Of these changes the asymmetries or differences in the levels of the pubic rami varied noticeably from the findings in the control group.

During pregnancy both the incidence and the extent of asymmetry was increased as compared to the control group:

50 per cent of the cases showed asymmetry of 1 mm. or more
30 per cent showed an asymmetry of 2 mm. or more
9 per cent showed an asymmetry of 3 mm. or more.

This finding is interpreted as evidence of increased mobility in the sacroiliacs and is a roentgenographic expression of the clinical observations of increased pubic mobility during pregnancy.

It is quite likely that had a technique

TABLE III

WIDTH OF SYMPHYSIS BEFORE AND AFTER DELIVERY

Before Delivery	Time Interval after Delivery	Before Delivery	Time Interval after Delivery
mm.		mm.	
5	4 mm. within two weeks	4	3 mm. within two weeks
5	3 mm. within two weeks	3	3 mm. within two weeks
9	5 mm. within two weeks	4	4 mm. within two weels
3	3 mm. within two weeks	5	4 mm. within two weeks
3	3 mm. within two weeks	10	7 mm. within two weeks
6	5 mm. within two weeks	4	4 mm. within two weeks
5	4 mm. within two weeks	5	5 mm. within two weeks
4	4 mm. within two weeks	18	3 mm. six months
4	4 mm. within two weeks	20	5 mm. five weeks
7	4 mm. within two weeks	8	5 mm. two months
7	3 mm. within two weeks	8	4 mm. four months
7	4 mm. within two weeks	8	4 mm. six weeks
6	6 mm. within two weeks	26	5 mm. six months
5	5 mm. within two weeks	10	5 mm. six weeks
5	5 mm. within two weeks	18	3 mm. six months
4	4 mm. within two weeks	20	5 mm. six weeks
5	3 mm. within two weeks	8	5 mm. two months
6	4 mm. within two weeks	8	4 mm. four months
10	4 mm. within two weeks	8	4 mm. six weeks
3	3 mm. within two weeks	22	6 mm. six weeks
3	3 mm. within two weeks	10	5 mm. six weeks

such as was described by Chamberlain been used, an even higher incidence of asymmetry would have been shown. However, even without this special technique, some degree of increase or of reversal of asymmetry was noted in 42 per cent of those cases showing the change and followed serially.

The incidence of arthritic changes was about the same in the pregnant as in the non-pregnant female group.

It was noted throughout the series that those cases which early in pregnancy showed rather marked asymmetry, particularly when this was associated with sclerotic changes in the pubic faces and lipping of the superior borders, showed little if any widening as pregnancy advanced. This arthritic type of symphysis is most commonly seen in elderly primiparas or in old women who have had numerous children. It may, however, occasionally be observed in young nulliparas or primiparas.

Asymmetry in these arthritic cases appears to be part of a pathological process and should be differentiated from the rotations which appear after relaxation has occurred.

Two further changes are occasionally noted in the pubic bones during pregnancy which have no parallel in the non-pregnant group. One is a slight rarefaction of the cortex bordering the cartilage and slight roughening of the superior margin of the pubic rami to either side of the midline.

The other is the appearance of small flecks of bone elevated from one or the other pubic faces. These are quite inconstant, are noted in the latter months of pregnancy and present an appearance suggestive of tear fracture. However, in no instance were they associated with symptoms.

Anatomical correlation of the observed roentgenographic findings is furnished by post-mortem studies of the symphysis pubis of women dying before, during and after labor.

Loeschcke found that the symphyses of women who have borne children present a distinctly different appearance than those found in men and in children. He describes exaggeration of the primary joint fissure with the formation of secondary fissures running through the layers of the interarticular discs, tearing parts of connective tissue from the cartilaginous covering of the bone. In 4 necropsies performed on multiparas within twenty-four hours after delivery, he found the symphyseal clefts gaping from 2–6 mm. and these could be pulled out to 1 cm. Accompanying these changes marked relaxation and ligamentous hypertrophy were noted. The ligaments had lost their whiteness and had become reddish-gray in color. This color

FIG. 4. J. S., aged thirty. Fourth pregnancy. A. Seven and one-half months, symphysis measures 13 mm. B. Nine months, symphysis measures 16 mm. Suggestion of elevated fleck of cortex from left pubic face. No associated symptoms. C. Six weeks post partum; symphysis measures 5 mm.

change resulted from a marked increase in the blood supply. In primiparas he found recent lacerations of the disc during the first eight days after delivery. Hemorrhages into the joint space accompany these lacerations. These evidences of trauma have even been noted after the delivery of a premature seven month baby, while in another case a full term infant passed through the birth canal without markedly injuring the symphysis. While theoretically it would seem possible that the interarticular disc might remain intact in the birth of a full term child where the pelvis was extremely wide and the child small no instance of this sort occurred in his series.

As a result of these obstetrical traumas, the interarticular disc may completely disappear or the fissures may develop an endothelial lining. Nutritional disturbances in the cartilaginous and ligamentous parts lead to varying degrees of degeneration.

In addition to post traumatic reactions he found evidences of ligamentous and osseous proliferation. The ligamentous attachments had become broadened and the cortical bone beneath them was thinned and roughened. The pubic faces showed zones of newly formed bone 2–8 mm. wide. This evidence of bone growth was observed even in a woman aged thirty-nine, was more marked during first pregnancies but recurred with each succeeding pregnancy and led to permanent widening of the pelvis.

Putschar also found extensive accessory fissure formation and cartilaginous fragmentation in women who had had children. With repeated pregnancies he was able to differentiate the old reactive fissures of former pregnancies from those newly formed.

In pregnant women he quite regularly found newly formed young connective tissue between periosteum and bone. This was best seen near the bone ends where in conjunction with osteoclastic activity it served to develop firm anchorage for the hyperplastic ligaments.

By special staining methods he demonstrated fatty infiltration in the ligaments in parturient women. This change was most marked in the posterior ligament and at times resulted in complete fatty degeneration. In older women who had had children, calcium deposits were noted replacing the areas of fatty infiltration. These areas of degeneration were inconstant and were

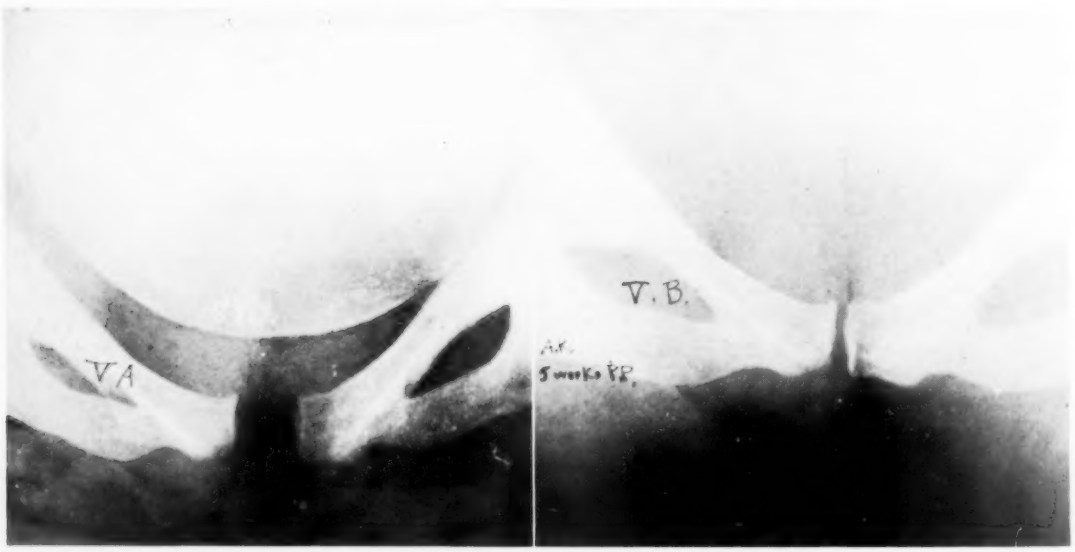

FIG. 5. A. K., aged thirty-six. Ninth pregnancy. A. Film taken at nine months; symphysis measures 20 mm. B. Film taken five weeks post partum; symphysis measures 3–4 mm. The bone ends are beginning to show arthritic changes.

more striking in women who had had children than those who had not.

The cartilaginous fragments within the joint may be completely absorbed and their space be replaced by a joint cavity containing an endothelial lining. In other instances they remain intact and are extruded from the joint usually on its posterior aspect. Here they resemble the cartilaginous nodules described by Schmorl on the posterior aspect of the intervertebral discs. Putschar was not, however, able to confirm Loeschcke's finding of increased pelvic widening as the result of bone growth. He noted evidences of ossification of the deeper layers of hyaline cartilage in both men and women. This ossification did not condition an enlargement of the pelvis for its growth occurred at the expense of the width of the hyaline cartilage.

Lang and Haslhofer feel that the so-called growth processes in the pelvic bones during pregnancy can be traced to reactive processes that arise from damage to the cartilage. These cartilaginous injuries are accompanied by vascularization and formation of bone in the deeper parts of the cartilage. They stress the occurrence of similar reactive changes in the sacroiliacs as the result of increased functional demands.

The ligamentous relaxation and enlargement of the joint space accompanying pregnancy render the symphysis more vulnerable to the multiple, small, functional traumas through an increase in mobility between the two sides of the pelvis. The constant irritation produced by this increased mobility, associated with the gradual degeneration and calcification of the deeper layers of hyaline cartilage, may eventually lead to changes identical with those seen in arthritis deformans. When these changes are complete the narrowed pubic space, sclerosed and cystic bone margins and ligamentous calcifications produce a rigid, unyielding symphysis.

On the other hand, the reparative and compensatory processes may lead to the development of an extensible joint space. The ligaments may retain their elasticity and their capacity of accommodation to varying functional demands. It therefore becomes apparent that the end-result of symphyseal change need not be the same in different individuals and it is quite likely that nutritional factors, particularly the condition of the local blood supply, is

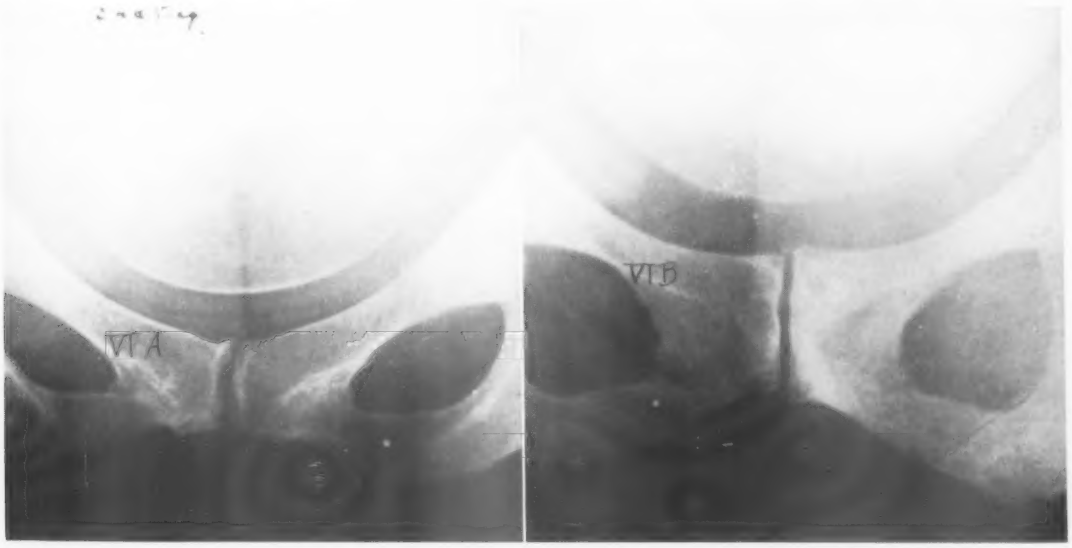

Fig. 6. Arthritic types of symphyses. A. Aged thirty-six. Second pregnancy. Symphysis measures 4 mm.; beginning sclerosis of bone edges with fringing of the superior borders. B. Aged forty. Eighth pregnancy. Symphysis measures 2 mm. Mixed changes of sclerosis and rarefaction in pubic faces. Fringing of borders.

largely responsible for the differences observed. In those who tend toward the arthritic type of end-result with joint rigidity and weakening of the ligamentous structures, we should expect that if widening occurred at all during future pregnancy or delivery it would be characterized by a sudden giving way; in other words, a rupture. This concept of local pathology predisposing to symphyseal rupture occurs several times throughout the pertinent literature.

On the other hand, in those cases where a distensible joint space is developed and healthy ligamentous tissues retained, we should expect relaxation and widening of the joint in future pregnancies. This relaxation, according to Lang and Haslhofer, prevents, to a certain degree, the forcible rupture of the ligaments which under usual physiological conditions are only slightly distensible.

The anatomical changes observed in the symphyses of pregnant and parturient women are for the most part extreme examples of those occurring in the joints of non-pregnant women and to a much less extent in men. Lang and Haslhofer say:

> Enlargement of the cavity of the symphysis pubis as a result of increased activity has been found in men following heavy work. Thus it follows that this increased mobility is chiefly caused by mechanical strains and changes of posture. . . . A distinction must be made between the changes due to trauma and those due to osteoarthritis deformans, as well as to secondary disease of the joints. . . . These effects of mechanical trauma are especially well seen in the terminal parts of the joints, they are characterized by numerous minute areas of damage, microscopic fractures, fissure and cyst formation and hemorrhages.
>
> The result of such injuries is the separation and rounding off of fragments and callus formation. Pregnancy affords the opportunity of slight traumas with sequelae similar to those first described in studies of arthritis deformans of the hip joint (Lang).

These arthritic manifestations are the same whether they occur in males, non-pregnant females or following pregnancy. Their roentgen appearances, narrowing, sclerosis, and fringing, have already been described. A marked predominence of these changes in females as compared to males is noted. In a portion of the non-pregnant group these can be easily explained as sequelae of past pregnancies. However, in the late epiphyseal group and women in whom no previous pregnancies had occurred, the incidence of early arthritic changes is almost as great as that occurring in the pregnancy or post pregnancy group.

The explanation of the occurrence of arthritic changes in women who have never had children is probably intimately connected with the minor degrees of pelvic relaxation noted during menstruation by Goldthwait and Osgood, and later by Chamberlain.

The outstanding anatomical difference not only in degree but in kind existing between the symphyses in pregnant and non-pregnant women appears to be those changes resulting from the lateral migration of the ligamentous attachments and associated osteoclastic activity occurring during pregnancy. Such changes might be expected to give roentgen evidence of their presence and since these ligamentous changes are demonstrable anatomically as early as the second or third month their regular appearance might be of aid in the early diagnosis of pregnancy. The entire series of approximately 400 roentgenograms taken in various stages of pregnancy and parturition were reviewed with this particular point in mind, and in a few of the cases examined serially an increased haziness of the pubic faces with slight rounding of the superior angles was noted. These changes were accompanied by a slight thinning of the cortex of the pubic faces.

Abramson, Roberts and Wilson remark on the finding of this haziness of the pubic faces. In the present series the finding is inconstant and because of the technical difficulties encountered during pregnancy its demonstration is not entirely satis-

factory. It was thought that films taken early in the post partum period or, better still, roentgenograms of post mortem material, should show these bone changes more definitely.

Among the post mortem material only two symphyses were obtained from pregnant women. One patient died following a Cesarean section at term. The other patient died as the result of an infected abortion at about the fifth month. In neither instance did films of the excised symphysis reveal any definite bone change which could be interpreted as resorption or growth.

In the post partum material 25 cases were examined within the first two weeks. In 3 of these slight rarefaction of the superior pubic border to either side of the symphysis was present. This extended out along the superior border for from 2–4 mm. and in one instance caused the disappearance of a small spur or fringe which was present in an earlier film. No evidence of bone growth was seen in any of the films.

Therefore, from the data at hand we are unable to confirm Loeschcke's finding of actual bone growth of the pubic rami during pregnancy. It would furthermore appear that the roentgenographic evidences of bone resorption and broadening of the ligamentous attachments are of too inconstant appearance to afford dependable negative or positive evidence of pregnancy.

ETIOLOGY

The causes of pelvic relaxation and symphyseal widening are probably multiple. Comparative anatomy furnishes many parallels and some opposites in behavior of the symphysis of lower animals.

The sinking of the rump in cows, a manifestation of sacroiliac relaxation, has long been recognized by veterinarians, (Snelling). The marked widening of the pelvis in guinea pigs and the resorption of the pubic rami in pocket gophers also represent nature's effort to facilitate delivery in animals whose young are relatively mature when born. The dog's pelvis, on the other hand, tends to undergo an early ankylosis (Loeschcke). There is therefore a species difference in the physiology of the pelvis.

Endocrine influences undoubtedly play a major rôle in the ligamentous relaxations of pregnancy and it is quite likely that they are also active in the minor relaxations of menstruation.

Hisaw, in particular, has demonstrated the effects of ovarian extracts on the symphysis.

In the castrated male pocket gopher he was able to reproduce resorption of the pubic rami, similar to that occurring in females, by the injection of aqueous extract of ovary.[25] He also demonstrated in guinea pigs that relaxation of the symphyseal ligaments was produced by a corpus luteum hormone, provided the animal had first been subject to the action of follicular hormone.[26] He further feminized castrated male guinea pigs by means of ovarian transplants and despite the fundamental difference in symphyseal structure between males and females of this species was able to produce some evidence of relaxation upon injecting corpus luteum or placental extracts.

Using the relaxation of the symphysis as an indicator for the presence of the hormone in the blood of pregnant animals, he found wide species variations in its content.

Blood from pregnant sows, dogs, cats and mares gave positive results while that of cows and women was entirely negative. The quantitative criterion used in this work was the dosage of serum required to produce relaxation when injected intraperitoneally into a guinea pig. The rabbit was found to rank first, requiring only 0.25 cc of serum to produce noticeable changes. This is very much better than guinea pig blood, which was found to be poor in the hormone, from 6 cc to 10 cc given in 2 cc doses for 3–4 days being necessary to cause even fair relaxation. It took nine 2 cc doses on as many consecutive days to produce a fair relaxation when dog serum was used. The blood of cats and sows was sufficiently potent so that 2 cc were ample to produce good positive results while that of the mare was poor. Just why the blood of

cows and women gave negative results is not clear.

At a later time extracts of the human and the cow placenta were made, but they had no noticeable effect on the guinea pig's pelvic ligaments.

In commenting on Hisaw's work Evans[27] says:

> Whether or not this factor (Relaxin) described by Hisaw is another separate hormone cannot be stated at this writing but there is no doubt that it does play a part in the relaxation of the symphysis pubis at the time of parturition.

While the specific relaxing hormone has not been found in the blood of women, the work of Frank[28] and his collaborators shows a definite increase in the circulating female sex hormone, both during pregnancy and to a less extent during the pre-menstrual period. Occasional cases of persistent relaxation which promptly return to normal after the removal of retained placental fragments give further support to the endocrine theory of relaxation. Such a case is reported by Cerné.[29] However, despite the convincing evidence in favor of an underlying endocrine mechanism in pelvic relaxation, the erratic behavior of the human symphysis requires additional explanation.

Frank's work has shown a marked increase in female sex hormone in a larger percentage of women than show marked pelvic relaxation. Multiparity is the most striking factor in the production of definite symphyseal widening and yet we find primiparas showing moderate degrees of widening and multiparas showing none at all.

With the thought that the presence or absence of male stigmas might furnish some indication as to the probable degree of relaxation an attempt was made to group the cases on this basis. The major degrees of widening were always associated with the female type of symphysis. However, while no extreme widening was found in cases showing male stigmas as indicated by a high pubic face, steep subpubic angle and heavy bone structure, a number of typically female types also showed little definite change.

The age of the patient seemed to have little bearing on the degree of widening. Elderly differed little from young primiparas in their pubic changes.

It therefore seems probable that the previously discussed anatomical differences are responsible for much of the observed variability in relaxation. That these anatomical differences may be in part at least dependent on variations in the pelvic vascularity is supported by the observations of both Potter and De Lee that relaxation is most marked in those individuals showing engorged pelvic veins.

In this series it has not been possible to prognosticate from films taken early in pregnancy which cases will show pubic widening as pregnancy advances. Neither has it been possible to foretell the extent to which widening will progress.

It has been possible in some instances to predict that widening probably would not occur. This prediction was based on the presence of arithritic manifestations in the pubic faces coupled with narrowing of the cartilage space.

SIGNIFICANCE

The importance of the changes occurring in the symphysis pubis can hardly be overestimated. As is apparent from an anatomical consideration that changes here must be associated with changes in the sacroiliacs, and a number of the writers on this subject have called attention to the parallel changes occurring in these latter joints. Furthermore relaxation of the pelvic joints appears to be only one of the skeletal manifestations of the influence of pregnancy. Taylor,[31] in discussing Snelling's presentation of this subject, quotes Coulson as teaching that the larger joints of the extremities may experience this relaxing or softening influence and says, "In one of my patients the left knee could be partially luxated during gestation."

More recently, von Schubert[32] has shown

by means of accurate roentgen measurements in the lateral projection that not only sacroiliac but lumbosacral mobility, as well, is increased during pregnancy.

The frequency and extent to which the ligamentous relaxation of pregnancy involves other joints is unknown. None of the other articular or ligamentous structures in the body present the possibilities of roentgenographic demonstration of relaxation found in the symphysis. Such relaxations in other joints would necessarily have to be well marked before the average clinical examination would reveal them.

The importance of the changes in the pelvic joints and lower spine as a cause of backache have been mentioned by nearly all writers on this subject. In addition, Goldthwait and Osgood, as well as Chamberlain, have called attention to the sacroiliac symptoms associated with menstrual relaxation.

An attempt was made to study the incidence of backache in the present series by means of questionnaires sent to the women who had been roentgenographed. The results of any investigation of this sort are not apt to be clear cut because of the many causes producing backache. It has been shown by Ward[33] in a study of 721 cases of backache in women that only about 15 per cent were of an orthopedic or non-surgical nature and 85 per cent were cured by appropriate gynecological operations. Jones and Lovett[34] say, "In cases of women it must be definitely recognized that backache of pelvic origin is often indistinguishable from static backache."

The answers to the present questionnaire seem to indicate that the degree and frequency of backache in those showing moderate pubic separation is no greater than in those who do not show this change.

This finding is probably to be explained by an absence of severe sacroiliac damage among the cases in this group.

Reis and his coworkers, in their analysis of cases of symphyseal rupture, found sacroiliac involvement 22 times in 67 cases. This was associated with symphyseal widening ranging from none to 3 cm. On the other hand, their tabulation of the cases reported by Hellinghaus shows a 5 cm. gap with no mention of sacroiliac involvement. It would seem that the production of sacroiliac symptoms in cases of relaxation as well as rupture is dependent not alone on the degree of widening but on the suddenness of its production and the presence or absence of ligamentous tears about the joint.

Of greater theoretical interest are the changes which arise from irritation incident to relaxation. As was shown by Lang and Haslhofer these present an appearance similar to that seen in arthritis deformans. Should relaxation be demonstrable in any appreciable percentage of joints other than those of the pelvis we should, on the basis of the changes demonstrated, be forced to consider this relaxation as a possible etiologic agent in the production of arthritic changes elsewhere. Such a consideration would not necessarily be limited to women but might include men as well since the female sex hormone may reach appreciable concentrations in male body fluids, particularly bile.

From the obstetrical standpoint the changes in the pelvic joints assume importance through their effect in facilitating delivery and through their influence on pelvimetric calculations. The first of these has been mentioned by De Lee. Eymer and Lang, in speaking of the slight residual widening of the pelvis following labors, say that an easy delivery following previous deliveries can be attributed not only to the absence of soft tissue difficulties but also primarily to the increased width of the pelvis.

A correlation of delivery time with degree of relaxation was not feasible in our series due to the fact that most of the cases were delivered by version and extraction. It is, however, problematical whether such a correlation, if made, would have any real significance in a series of this size. The varying forces of expulsion, condition of the soft parts, presentation and size of the

baby would present obstacles to correlation of such magnitude as to render conclusions hazardous.

The absolute increase in pelvic diameters in cases showing relaxation is self-evident and advantages undoubtedly result from the associated increased pelvic mobility but an accurate correlation between degree of widening and ease of delivery will require the analysis of many hundred cases.

Whether the therapeutic production of varying degrees of pelvic relaxation will become practical in the future is not known. The thought, however, presents fascinating possibilities in the control of minor degrees of pelvic contraction and deformity.

The occurrence of pelvic relaxation and consequent widening must be recognized in connection with roentgen pelvimetry. An extensive literature has grown up about this subject in recent years and a high degree of accuracy is reported in calculating the diameters of the pelvic inlet. This literature,* however, ignores the occurrence of pelvic widening during the later stages of pregnancy. Pelvic measurements taken in the non-pregnant or early pregnancy periods should therefore be regarded as minimums which may or may not be altered by widening. It would furthermore seem advisable to examine during the late rather than the early months of pregnancy. This is particularly so in the case of individuals having pelves of questionable capacity.

SUMMARY

A study of the symphysis pubis in pregnant and non-pregnant females reveals much of importance from the anatomical, medical, orthopedic and obstetrical standpoints.

The pelvic relaxation occurring during pregnancy in between 50 and 60 per cent of cases produces varying degrees of increase in the pelvic diameters. It appears to result from the action of ovarian hormones on the ligamentous structures. The degree of relaxation seems at least partly dependent on local anatomical conditions.

Pregnancy relaxation results in an increase in pelvic mobility and the traumas of delivery always leave anatomical evidences of their presence. The reparative processes following irritation incident to increased mobility and delivery trauma may lead in either one of two directions: (1) restitution to a normal or nearly normal condition of the ligaments with the development of distensible joints, or (2) abortive repair with the development of changes identical with those found in arthritis deformans.

While these changes may involve all of the pelvic joints, they are best demonstrated roentgenographically at the symphysis.

The changes found in the symphyses of pregnant and parturient women are for the most part extreme degrees of those occurring as the result of severe functional demands in males and non-pregnant females.

There is some evidence that the ligamentous relaxation of pregnancy may involve other joints than those of the pelvis and there is no reason to believe that the sequelae in these joints will differ in type from those found in the pelvis.

Since the causative agent of these relaxations is intimately related to the female sex hormone and since this hormone is demonstrable both in premenstrual blood and male body fluids, notably bile, it is logical to expect that similar reactions of a milder degree would occur in non-pregnant females and at times in males.

Just what part these relaxations may play in the production of arthritic changes in other than the pelvic joints cannot be determined from this study.

Pelvic widening, when it occurs during pregnancy, may increase up to the time of delivery. While clinical symptoms have been reported accompanying relaxation, no cases of this type occurred in this series.

Restitution to normal width following delivery is quite prompt, usually being complete within two weeks post partum. None of the cases covered in this report

* References 35 to 50.

received orthopedic treatment other than the usual post partum pelvic binder.

The effect of pelvic widening on time of delivery could not be established in this series.

Cognizance should be taken of pelvic relaxation and possible widening in the performance of roentgen pelvimetry.

I wish to express my appreciation to Drs. Irving and Milton Potter for their aid in making this material available for study.

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A CASE OF ATYPICAL PERTHES' DISEASE*

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A BOY, aged twelve, was admitted to the hospital in November, 1930, complaining of tenderness in the region of the right hip. In July, 1930, while running, he suddenly fell and strained the right hip. The patient could not give accurate details of the injury. Two days later he complained of pain and some stiffness of the joint. He could not flex the hip, especially when in sitting position. There was slight limp to the right side in walking. A few days later some improvement was noticed and active muscle power increased. There was no loss of body weight.

Examination showed a well-developed healthy appearing boy. There was shortening of about one-half inch of the right lower extremity and one-half inch atrophy of the thigh. There was some limitation of internal rotation and abduction. Flexion and internal rotation caused pain. The Trendelenburg sign was present on the right. He walked with very slight limp. Calcium and phosphorus determinations were within normal limits. Tuberculin tests were negative on two occasions. (Roentgen findings appear below.) Impression at this time was Perthes' disease. Physiotherapy was begun.

The patient was seen again in our clinic in January and February, 1931, when he showed slight elevation of temperature. Roentgen findings were more pronounced. There was some infiltration in the anterior aspect of the hip joint, and the thigh was held in an attitude of 30° flexion and 20° abduction, and some external rotation. Abduction and flexion were limited and there was no internal rotation. A single hip spica was applied. One month later the swelling about the hip joint had decreased, but was still present in May, 1931. Because of the persistent swelling and increase in temperature, an incision and drainage were considered. The white blood count was 6,050. It was therefore decided to continue with immobilization in a plaster cast. In February, 1932, the hip spica was removed and examination showed a fair range of motion, except in abduction, which was markedly limited. There was no tenderness. There was shortening of 1 inch. Examination in November, 1932, showed the patient to be in very good condition, temperature normal. There was atrophy of about 2 inches in the right thigh, 5 inches above the patella. Shortening had increased to $1\frac{1}{2}$ inches. The hip joint seemed quiescent. Flexion, adduction and internal rotation were markedly limited, but abduction and external rotation were almost free. Patient had a marked limp to the right side, but did not complain of pain in walking.

Roentgen findings were as follows: November, 1930—Distinct flattening of the femoral head and decrease in the height of the central part of the femoral epiphysis. A small fracture line was seen in the subchondral region near the apex of the head. The lateral pole of the epiphysis was markedly porotic and irregular in structure. The outline of the joint surface over the lateral pole was smooth and distinctly elevated compared with the central depressed portion. In the middle portion of the epiphysis and just below the flattened area a dark shadow could be seen. The joint space was widened; the acetabulum appeared normal as well as the epiphyseal plates of the femoral neck and trochanter.

January, 1931 (Fig. 1)—The findings were essentially the same except for a slight increase in osteoporosis of the epiphysis at its lateral pole.

February, 1931 (Fig. 2)—The shadow in the central portion of the epiphysis seemed to be increasing in density as compared with the surrounding atrophic bone. The subchondral fracture line was still visible.

April, 1931 (Fig. 3)—The most striking feature at this time was the presence of a more or less wedge-shaped, very dark and almost homogeneous area in the epiphysis, the base of which was formed by the flattened portion of the joint surface. The apex of this wedge appeared to cross the epiphyseal plate and to reach the juxta-epiphyseal portion of the femoral neck. The lateral epiphyseal pole was osteoporotic and distinctly more prominent toward the joint space than it was in the previous roentgenograms. The femoral head was outwardly subluxated to a slight degree. The

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FIG. 1

medial part of the epiphysis showed almost the same degree of osteoporosis as the lateral one; it was separated from the central part by a zone of marked osteoporosis. The central part appeared therefore like a sequestrum. Lateral subluxation was present as in the previous film; the epiphyseal plate appeared to be disintegrating. The epiphyseal plate of the greater trochanter showed a similar finding. The femoral neck had slightly increased in thickness and a coxa vara was beginning to appear as compared with the findings in the opposite hip.

November, 1931 (Figs. 4 and 5)—The dark central shadow had completely disappeared and the epiphyseal part with its trough-shaped joint surface showed the same density as did the lateral pole. Good bone trabeculae passed from the mesial portion to the lateral pole. The central portion of the epiphysis, however, was separated from the medial pole by a slightly irregular, but rather osteosclerotic zone, which continued along the line of the epiphyseal plate to the lateral pole. Proximal to this part of the osteosclerotic zone was a narrow border of osteoporosis. A distinct epiphyseal plate could be seen only in the lateral pole. The epiphyseal plate beyond the greater trochanter was narrowed, but still present. The outline of the roof of the acetabulum was quite irregular and its bone was markedly porotic.

FIG. 2

FIG. 3

February, 1932 (Fig. 6)—Findings were essentially the same. The bone structure, however, appeared much clearer, although porosis was still present. The central portion showed a sharp but irregular wavy outline. The width of the joint space was normal. The shortening and thickening of the femoral neck were still present. The epiphyseal plate had disappeared.

June and November, 1932 (Fig. 7)—There was a slight increase in the height of the central portion which is surrounded by a rather bony osteosclerotic demarcation zone. This osteosclerotic zone was paralleled by a narrow osteoporotic zone. All of the epiphyseal plates were occluded. Coxa vara and coxa plana were present.

Fig. 4

Fig. 5

Clinically and roentgenologically, one meets some difficulty in making a diagnosis in this case. It resembles mostly a Perthes' disease and it was this diagnosis that was given in the above case.

Perthes' disease is coming more and more to be thought of as an aseptic necrosis of the femoral head, probably traumatic in nature. It is true, however, that the history of trauma is not always clear cut and frequently there is no history of trauma whatsoever. In a series of 9 cases, observed in the Istituto Rizzoli in Bologna, in an early stage of the disease (first three months), 3 showed distinct fracture lines in the subchondral zones of the femoral head. Roentgenologically, there were no other findings of significance, and it was concluded therefore that the fractures represented primary lesions upon which, or simultaneously, aseptic necrosis developed.

A distinct fracture line in the subchondral zone was also well visible in the first roentgen studies of the hip joint in this case, and the patient was very decisive about his trauma. The exact mechanism of

Fig. 6

Fig. 7

the trauma, as was stated above, is not clear but we believe that a compression fracture occurred bringing about an aseptic necrosis of the bone. It appears that not the entire femoral epiphysis was involved as is usually true in a definite case of Perthes' disease. Here, only the central portion of the epiphysis which lies just below the outer edge of the acetabulum was affected by aseptic necrosis. The compression fracture of the central portion of the epiphysis led to a decrease of the central portion of the head and a slight increase of the roentgen shadow.

In our case, as is true in Perthes' disease, the roentgenological changes of the hip joint (especially of the femoral head) are not pathological per se; they are rather an expression of a reorganization, i.e., a healing process going on in the necrotic areas and sustained by the healthy tissue. The dead bone becomes resorbed by fibrous marrow, which finds its origin in the border between the neck and the head of the femur. This is seen in the porotic areas of the epiphyseal poles in the early stages of the disease. Slowly, the resorption of the dead bone is followed by new bone production. Because of the osteoporosis of the epiphyseal margins the central portion which is not yet invaded by the reorganizing fibrous bone marrow appears relatively darker in the subsequent roentgenograms. It assumes, in our case, more and more the wedge-shaped appearance of the sequestrum. The increased shadow, cast by the central portion, is due to the comparatively atrophic nature of the surrounding parts together with a filling out or plugging up of the marrow spaces by small bone fragments and bone detritus which arises at the site of fracture. The fracture line itself disappears rather early in the roentgen series. This should not be interpreted as a complete healing of the fracture because it is impossible for bony callus to be produced in the necrotic zone. The fracture space itself becomes filled out with fragments of bony trabeculae as do the marrow spaces, and therefore disappears.

In a short time the necrotic bone becomes reorganized. The area of increased density gradually disappears and becomes replaced first by rather porotic bone tissue. The reorganization, however, does not lead to a perfect anatomical restoration. While the healing process is going on, it must be remembered that this area is relatively soft and cannot withstand well the pressure exerted upon it by the edge of the roof of the acetabulum. The joint surface therefore becomes more trough-like at its central portion. Proof of this supposition lies in the fact that the lateral subluxated pole lacks contact with the acetabulum and the pressure is not exerted upon it from above. Following its organization, it is therefore free to increase in height. The medial portion of the epiphysis preserves its original shape and almost its normal structure during the whole time of the healing process because it is apparently free from aseptic necrosis.

Roentgenologically, the joint cartilage in our case seems as in the cases of Perthes' disease—uninvolved. The joint space does not become narrowed. The earlier roentgenograms showed even a widening of the joint space as compared with that of the normal side. From the clinical viewpoint, however, the joint space itself showed more pronounced changes than we see in the average case of Perthes' disease. The swelling of the hip region, the tenderness, the marked limitation of motion and the increase of temperature pointed to an infectious process and drainage was considered. (Tuberculin test—twice negative.)

A low grade osteomyelitis followed by sympathetic joint effusion must be considered as a possibility in this case. The disappearance of the epiphyseal plates and the clinical course of the disease are in support of this view. In the early roentgenograms no changes in the epiphyseal plates or in the juxta-epiphyseal portion of the neck could be seen. There were no signs of a circumscribed or a diffuse osteoporosis as it is frequently seen in Perthes' disease. In May, 1931, it did seem, nevertheless,

that the apex of the wedge-shaped area crossed the epiphyseal plate and reached the juxta-epiphyseal portion of the neck. This portion became resorbed quickly but was followed by disintegration of the epiphyseal plate between the head and neck and also of the epiphyseal plate of the greater trochanter. The disintegration of these plates led to a shortening of the limb of more than $1\frac{1}{2}$ inches. On the basis of these changes it seems that Perthes' disease can be ruled out. Disintegration of the epiphyseal plate and shortening of the leg to such an extent is not the usual finding in Perthes' disease.

There are two possibilities in this case which might serve to explain the rather uncommon clinical and roentgen findings. First, a compression fracture of the central portion of the femoral head as a result of trauma and leading to an aseptic necrosis of this area; second, a relatively mild nonsuppurative osteomyelitis developing in a traumatized area of decreased resistance. In support of the latter view are the increase in temperature and the premature disappearance. The traumatic factor is easily proved by the history.

If one were to judge this case on one of the lateral roentgenograms alone (for instance, June, 1932), a diagnosis of osteochondritis dissecans of the femoral head might easily be made. There have already been a few cases observed which showed a more or less lentil-shaped area immediately below the joint surface and surrounded distally by a zone of porosis and a zone of sclerosis. These zones are demonstrable in our case. The roentgen shadows in a real case of osteochondritis dissecans are always more marked than those of the surrounding areas. In our case this area is markedly porotic and the osteoporosis alone suggests that we are not dealing with a necrotic bone area undergoing dissection, but rather with one which was previously necrotic and subsequently replaced by new bone tissue. For some reason, it has not yet become homogeneously fused with the surrounding cancellous bone.

In a previous article[2] I reported a case which resembled an osteochondritis dissecans even more than this case does, and I suggested for such a lesion the term pseudo-osteochondritis dissecans.

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A DEMONSTRATION OF RENAL LYMPHATIC VESSELS*

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THE urologic literature contains a number of records concerning chyluria. In one of these, reported by Wood in 1929, perirenal lymphatic vessels were demonstrated roentgenographically and thus in this instance the secretory theory of chyluria seemed eliminated from consideration with the assumed demonstration of fistulous connections between the lymphatics and the urinary passages.

Fillis and Exley each reported a similar demonstration of "pyelolymphatic backflow" or "perirenal lymphatics."

Recently we observed on two occasions escape of pyelographic fluid into the renal lymphatics. One of these records is submitted; the second is not reported as the demonstration was less striking and the fine detail would have been lost in the reproductions.

FIG. 1

CASE REPORT

R. F., white, aged forty-five, business man, was injured by a handball, which struck him at rather high velocity in the dorsolumbar region. He recovered soon from shock and continued his business activities for two weeks. Then a fairly marked hematuria developed, on account of which he entered the hospital (service of Drs. J. G. Israel and H. W. Plaggemeyer). On May 25, 1933, instrumental pyelography was carried out (Fig. 1). For three weeks afterward the patient ran a septic course, developed an epididymitis, and for a time a doughy resistance was palpated in the right renal fossa, which was suspected of being due to a developing perinephritic abscess; this, however, gradually disappeared without surgical interference. Later on, osteomyelitis of the left humeral shaft occurred, which healed within a reasonable time after saucerization. During this illness the patient also suffered a fairly extensive and severe burn to the left upper extremity, which resulted in considerable contraction of the hand. At present there are no symptoms referable to the urinary system. Hematuria was not observed any more three weeks after pyelography.

This patient never lived in a tropical climate; he gives no history of filaria infestation; chyluria was not observed at any time.

Pyelography was performed very gently without any force and a total of 7 c.c. of fluid was used for visualization of the renal pelvis and ureter. Figure 1 shows considerable extravasation of pyelographic fluid from the renal calyces into the papillary ducts and collecting tubules. Four fine vessels are outlined emerging from behind the upper infundibulum and extending obliquely in a cephalic-median direction, converging toward one larger trunk.

Our opinion of "pyelolymphatic backflow" was confirmed when Dr. C. A. Waters of Baltimore drew our attention to the paper of Wood.

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In the second instance of demonstration of renal lymphatics which we have observed in this department extravasation of opaque material into the renal ducts and tubules was much more extensive, so as to partly overshadow the fine vessels and produce quite a blurred image of the infundibula and calyces.

We do not intend to enter into the discussion of the mechanism of chyluria—secretory theory versus assumption of fistulous connections between perirenal lymphatics and the renal excretory system—but we feel that images like the one reproduced herewith must not of necessity be interpreted as indicating a true fistulous connection between the secretory renal elements and the renal lymphatics. One should not offhand deny that absorption of such foreign material as NaI might take place within the kidney, especially when in appreciable amounts it enters the papillary ducts and collecting tubules, possibly even higher spaces; in the case of such absorption, the renal lymphatics could become demonstrable roentgenologically without the presence of the assumed fistulous connections.

The stormy course of this patient following pyelographic investigation emphasizes again the necessity of utmost gentleness and careful asepsis during injections of the renal pelvis; it should also be a repetition of the warning against the use of contrast media which are not tolerated in the blood stream and are likely to induce embolism or thrombosis. Factors which may lead to patency of pyramidal papillary ducts are not sufficiently known and cannot be predicted. The relation of injury to hematuria occurring fourteen days afterward is doubtful, though it may have to be considered.

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THE DANGERS OF ROENTGENOSCOPY AND METHODS OF PROTECTION AGAINST THEM*

I. GENERAL REVIEW OF THE PROBLEM

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THE great value of roentgenoscopy as a diagnostic procedure lies in the direct view it furnishes of the examined part. It is possible to observe the viscus from many angles, to note its normal and abnormal movements, and, with the aid of palpation, to obtain much additional and important information. The helpfulness of palpation under the roentgenoscope in arriving at a diagnosis is so great that gastrointestinal diagnosis at The Mayo Clinic rests chiefly on roentgenoscopic procedures, and roentgenograms are made, in general, only as a confirmatory measure, or for record.

The fact that injuries to the skin from the use of roentgen rays so frequently noted among the earlier workers, were almost always limited to the hands, and occasionally to the face and neck, while the trunk and arms remained normal, has excited frequent comment and much speculation. The most common explanation is that the clothing must filter out a considerable amount, if not all, of the damaging rays. This theory led Carman, then chief of the Section on Roentgenology at The Mayo Clinic, to abandon the use of lead-rubber gloves in 1918, as he reasoned that the buckskin of the gloves he used was sufficient protection against the dangerous component of the rays emerging from the patient. Since then, the practice in the section has been to rely on ordinary leather driving gloves, street clothing, and celerity of examination rather than on lead-rubber screens, aprons and gloves as protection against radiation. The opinion of physicians in the section is that lead-rubber gloves are so bulky and stiff that their use robs the fingers of the all important tactile sense. Moreover, they cast a dense shadow which always obliterates a large portion of the finer details, the elicitation of which is the principal reason for deep palpation. This is particularly true when a small field is used. Thus, the use of lead-rubber gloves is thought to prolong to a dangerous extent the exposure of the patient and operator.

Since at no time has any of the physicians who conducts roentgenoscopic examinations at this clinic shown the slightest evidence of any injury, either subjectively or objectively, at his annual physical examination, the following study was undertaken to find the explanation for the apparent "immunity" of these men to roentgen-ray injuries.

The roentgenoscopic apparatus, if described from a therapeutic point of view, may be said to incorporate the following factors, 85 kv., peak, 3 to 4 ma., 38 cm. distance, 0.5 mm. aluminum plus 1 cm. plywood filter. With this set up, the skin erythema dose is 400 r (measured in air) with the roentgenometer used by us. All roentgenoscopic examinations are carried out at the fixed potential (85 kv. p.); the tube current varies from 2.5 to 5 ma., depending on the individual examiner.

In order to arrive at what might be con-

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sidered a fair average applying to 80 per cent of the examinations, we made a close study of the technique of roentgenoscopic examination of the gastrointestinal tract (Fig. 1).

The first swallow of barium is watched by the roentgenoscopist as it passes down the esophagus into the stomach. During this procedure the palpating hand is shielded by the screen. As the barium continues to flow into the stomach it is spread around by deep palpation and the pattern of the mucosal relief is studied. This is done so rapidly that by the time the patient has finished drinking the 8 ounces (240 c.c.) of barium meal, the procedure is completed and the palpating hand, now well protected by the partly filled stomach, is engaged in exploring the lesser curvature and the antrum through approximation of the walls of this portion of the stomach. This portion of the examination finished, the beam is swung over the region of the duodenum and pressure is applied on the stomach for the purpose of filling the duodenum. Once filled, the walls of the duodenum are approximated, if possible by deep pressure, the organ is refilled, and the examination is considered complete.

The steps of this examination are readily timed by the integrating time clock, placed in the primary circuit of the roentgen-ray machine, and activated by the foot switch. It has been found, by checking up several hundred examinations made by the several physicians in the department, that the actual activation of the roentgen-ray tube lasts, on the average, a few seconds more than one and a half minutes and very rarely more than two and a half minutes, but the total time of examination during which the patient is in the roentgenoscopic room is often very much longer. The total time of activation of the roentgen-ray tube

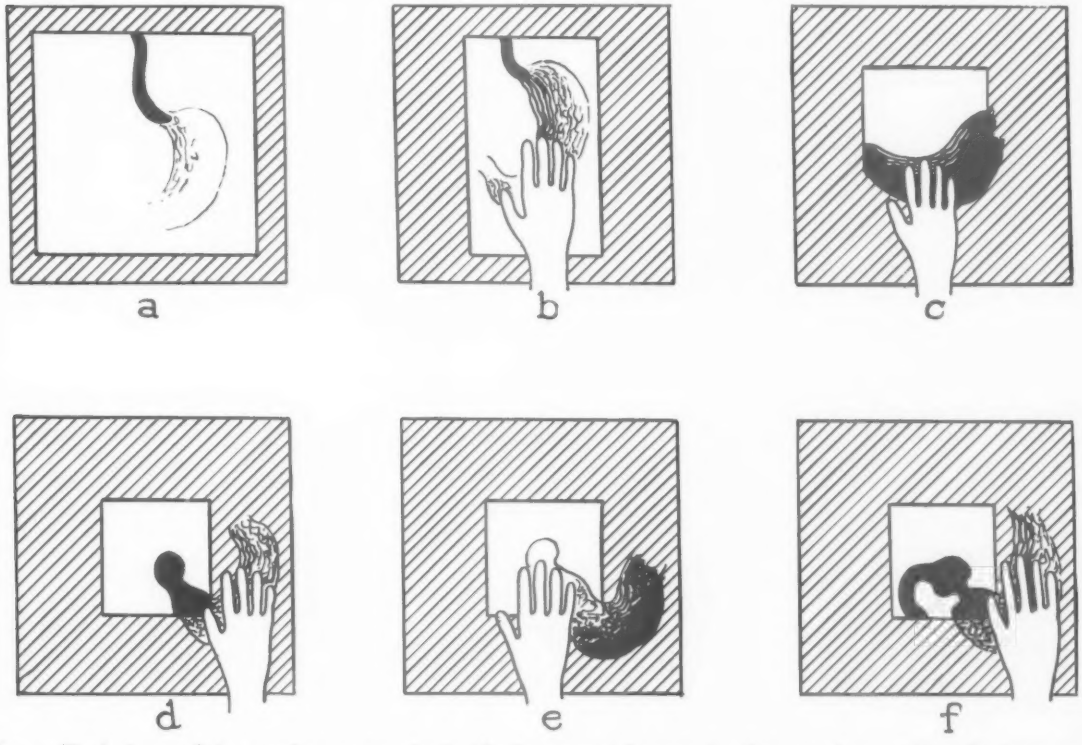

Fig. 1. Technique of the routine, one and a half minute gastric examination: *a*, observation of opaque meal passing down esophagus and entering stomach (time, five seconds). The hands are shielded by the screen; *b*, deep palpation for elicitation of mucosal relief (time, fifteen seconds); *c*, exploration of lesser curvature (time, twenty seconds); *d*, filling duodenum (time, forty seconds). Palpating hand is outside direct beam; *e*, approximation of walls of duodenum (time, five seconds); *f*, refilling duodenum (time, five seconds).

is divided as follows: study of the esophagus and cardiac end of the stomach, five seconds; study of the mucosal relief, fifteen seconds; exploration of the lesser curvature, twenty seconds; filling the duodenum, forty-five seconds; study of the duodenal relief, five seconds. The beam is frequently larger than 10 cm. square and is frequently much smaller.

Four factors are emphasized by the physicians in the section: the use of the smallest possible beam, celerity of examination, full use of the protective effect of the barium-filled viscus, and absence of exposure aside from that received while actually engaged in roentgenoscopy. As has been said, the operator wears no protective devices, except a leather driving glove on the examining hand. The daily exposure is spread over two and a half hours at most, it is usually one hour and a half or less, depending on the number of patients to be examined. Thus, instead of a dose spread out over an eight-hour day with a sixteen-hour period of recovery, these men receive their entire exposure in a massive dose, as it were, with a twenty-one hour period of recovery. We are not prepared to speculate as to which of the two types of exposure of this magnitude is the more dangerous.

For the purpose of determining the dose received by the examining hands of these men, we used both an ionization and a photographic system of measurement. Since it is obviously impossible to carry out all measurements during the actual examination of patients we used a wax phantom to reproduce as far as possible the patient as he is presented for examination. The Victoreen roentgenometer we used was found to have, by our checkup, confirmed by that of the factory, an error of less than 3 per cent with the type of radiation which we considered. For the photographic measurements we used films supplied by the Eastman Kodak Company which we exposed to known quantities of roentgen rays and compared them to test films processed at the same time and read in a Sheard-Sanford photolometer. For the sake of conservatism we admit an error of 40 per cent in our photographic measurements. The actual error, as a matter of fact, is considerably lower than the arbitrary figure we have assumed.

In this paper we will consider only the leather gloved hand of the examiner; this is the part of the body which receives the greatest dose of roentgen rays in the gastrointestinal roentgenoscopic technique used at the clinic.

Superficially, since the gloved hand in the principal beam during roentgenoscopy does not cast sufficient shadow to interfere with visualization of the viscus under examination, the leather glove would appear to be of negligible protective value. Moreover, in the same beam the empty glove casts a barely discernible shadow on the screen, not at all comparable to that cast by 0.5 mm. aluminum. The fact that the beam emerging from the 23 cm. wax phantom has a quality of about half-layer value of 4.5 mm. aluminum, and that 1 mm. aluminum has a filtration equal to about 1 cm. of sole leather are additional reasons for suspecting that thin buckskin gloves are of almost no value as a protective measure. In view of the thickness of this buckskin, which should have about the same filtration value as human skin, it seems probable that any rays soft enough to be filtered out by such a medium would hardly penetrate deeply enough in any case to effect the severe injury against which we wish to protect, because even though the gloves are not always buttoned, erythema at the wrist or palm has never been observed by these men.

Nevertheless, we decided to make an exhaustive study of the protective value of these gloves by using our Victoreen roentgenometer, and duplitized roentgen-ray films. Accordingly, the 2 c.c. bakelite ionization chamber was placed in front of the vertical roentgenoscope and exposed to the direct beam, using the standard setting for roentgenoscopy. The full scale of the instrument was discharged in 70.9 seconds on an average of six readings. Then,

changing none of the factors of the setup, one of the gloves was placed over the 2 c.c. chamber. The glove was of such a size that the chamber fitted somewhat loosely into the second finger of the glove. Thus, the chamber and a considerable portion of the supporting arm were completely surrounded by the leather. Another group of measurements was made; this time the average of the times of discharge of the chamber was 70.5 seconds, that is, 0.4 seconds faster than in the case of the uncovered chamber. These measurements agree within the limits of accuracy of the setup. The gloves were then measured to see if they protected against the rays that had passed through the patient. It is conceivable that the scattered and secondary component of a beam might be soft enough to render the gloves of some protective value. Accordingly, the 2 c.c. ionization chamber was set up in front of the 21 cm. phantom which was placed in the position the patient assumes in examination. Again the chamber was irradiated several times, both covered and uncovered by the glove, and again the times of discharge, 740.5 and 738.0 seconds (for 5 r), were within the limits of accuracy of the setup. As these measurements were checked many times during the course of the experiment, with the same result, it seems apparent that the glove offers no protection that can be shown by this method.

Both measurements were made in the path of the direct beam passing through the patient, represented by the phantom, so that the behavior of the glove to the purely scattered and secondary rays was checked up next. For these measurements the phantom was placed on the horizontal roentgenoscope and the 500 c.c. chamber was placed some distance to one side of the phantom. The beam was adjusted so that 5 cm. of wax at the top of the phantom was interposed between the edge of the beam and the edge of the phantom on the side nearest the chamber. In this position the chamber discharged 25 r in 160 seconds. Since it is impossible to place this chamber in a glove it was wrapped in a strip of glove-tanned horsehide and more readings were made. This time 25 r was measured in 158 seconds. Again, the readings of the discharge times agreed to the limit of accuracy of the setup. The horsehide we used was 7/1000 inch (0.18 mm.) thicker than the leather in three gloves used for comparison. A screw micrometer was used to measure the thickness of the leather.

Since it might be possible that the walls of the chamber would filter out any rays soft enough to be materially affected by the glove leather, a further series of measurements was made.

Eastman dental films and a piece of 8 by 10 film wrapped in black paper were placed on the phantom, some in the glove, some on the wax. They were exposed simultaneously through the phantom and were developed together. They were all equally darkened. The experiment was repeated; this time the films were placed half inside the glove and half outside, and all were exposed simultaneously. Again, no difference in darkening could be made out between the halves of the individual films.

In order that the wrapping of the films might be discounted, 8 by 10 duplitized films were placed in the dark room in lightproof containers, and were brought to the roentgenoscopic room. The setup was arranged as before, and the films were taken out of the containers in the dark and were exposed to roentgen rays without covering of any kind. For this procedure each film was cut nearly through on two parallel lines with scissors (Fig. 2). This produced three parallel projections of film united at the base like the fingers projecting from the palm. The films were so arranged that one "finger" was in the leather glove, one "finger" was uncovered on the block of wax, and the other "finger" was in a standard lead-rubber glove. The plan in this latter case was to determine the presence or absence of scattering from the lead-rubber. The "fingers" and their covering gloves were so arranged that, as in the case of the dental films, the distal half of the

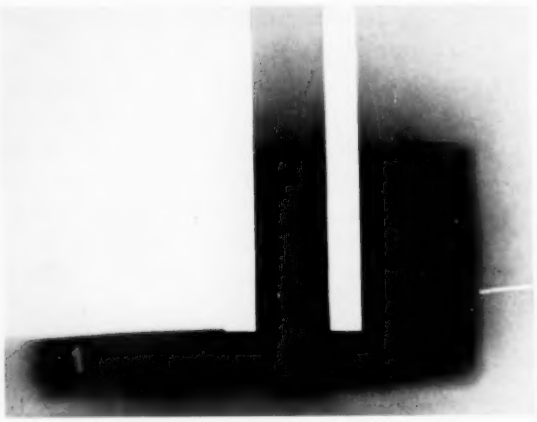

FIG. 2. Film cut nearly through in two places and exposed on phantom under conditions of routine roentgenoscopy. Projection No. 1 was placed in lead-rubber glove, projection No. 2 was uncovered, and projection No. 3 was placed in one of the leather gloves. That the leather glove casts no appreciable shadow and therefore offers negligible protection may be noted.

"finger" projected into the direct beam. Six films were exposed to varying intensities of roentgen rays, and in all cases the result was the same. The individual films varied greatly as to blackness, but the "fingers" covered by the glove and uncovered on the block of wax were identically black, whereas the "finger" placed in the lead-rubber glove (0.75 mm. lead equivalent) was unblackened, with no fogging demonstrable. In each case the "palm" of the film lying well outside the direct beam was perceptibly, though variably, blackened (depending on the exposure factors) and served, with the "finger" placed within the lead-rubber glove, as a check against possible fogging from outside sources of light.

Then a number of 8 by 10 films were exposed to varying intensities of roentgen rays on the wax phantom as before, except that, in place of the gloves, a piece of glove-tanned horsehide, a strip of aluminum 0.5 mm. thick, a strip of adhesive tape holding a number of thin lead-rubber shavings, and a piece of lead-rubber of 0.5 mm. lead equivalent were placed side by side on the wax block about 1 cm. apart (Fig. 3). Thus, each strip was surrounded by an appreciable area of uncovered wax. The films were exposed and developed as before. The individual films revealed a wide range of blackening. In all cases the lead-rubber strips were identified as an area of "unexposed" film, serving as a check as to the presence of outside "vagabond" exposure. The aluminum and adhesive tape cast faint, although definite shadows, but the outline of the leather could not be distinguished from the surrounding area of uncovered wax. As the outlines of the visible strips were hazy in some areas a supplementary series of films was exposed in the same manner, except that contact was assured by the application of a soft pad over the film to hold it against the wax. Of eight films so exposed, two showed a faint outline of the leather strip. The other strips appeared as before, but with somewhat more definite borders.

Next, on the chance that the scattered and secondary rays from the wax block might show an appreciable difference in quality from those generated in man, several subjects offered themselves and replaced the phantom, the experiment being

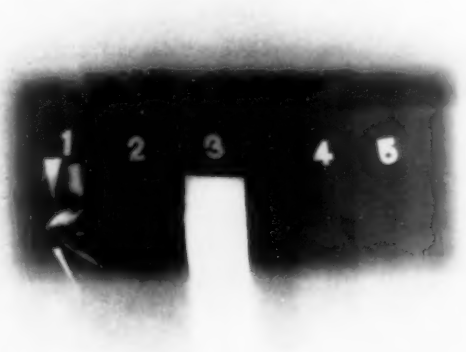

FIG. 3. Uncovered film exposed on phantom under conditions of routine roentgenoscopy: (1) strip of adhesive tape on which were distributed thin, lead-rubber shavings, (2) strip of glove, tanned horse-hide, somewhat thicker than leather of gloves in use in Section on Roentgenology, (3) strip of lead-rubber, (4) aluminum 0.5 mm. thick, (5) aluminum 1.5 mm. thick. The leather casts no shadow, and therefore is of negligible protective value.

thus repeated with four volunteers. In none of the films exposed as they were on the phantom could the outlines of the horsehide be made out. The bare film will measure longer wave length rays than can be measured by the ionization chamber. Since the sensitivity of the photographic film is only slightly changed by changes in wave length through the roentgen ray and ultraviolet range down to visible light, it is reasonable to conclude that the protective effect of the buckskin gloves is negligible.

Finally, one of us exposed the dorsal surface of his forearm to an erythema dose of roentgen rays generated at 80 kv. p., without filter. Three areas. 3 by 3 cm., were exposed simultaneously. The upper one was covered by a piece cut from the back of one of the buckskin gloves in question, the middle one was left uncovered, and the third (the distal field) was covered by a strip of 0.5 mm. aluminum. There was no well-marked difference in the reactions in the three fields (Fig. 4). Since roentgen rays generated at this potential and filtered by 1 mm. cardboard have a half-layer value of 2.5 mm. ($\pm$0.5 mm.) aluminum, and rays emanating from the phantom have a half-layer value of 4.5 mm. ($\pm$0.5 mm.) aluminum, measured photographically, we decided that the leather glove need not figure as a factor in our calculations of the dosage received by the men in the Section on Roentgenology.

Viewed in this light, it seems as reasonable to assume that the face, neck and hands of the earlier workers suffered because they were the parts exposed in the direct beam passing through the patient's body as it is to assume that they suffered because they were unprotected by clothing.

It is obvious that it is virtually impossible even if a very large beam is used, to expose the hand and the wrist proximal to about the level of the coat sleeve in the direct path of the roentgen rays during the ordinary manipulation of the stomach, or during the setting of a fracture, or during the search for a foreign body. This can be demonstrated by anyone to his own satisfaction. Further, when using an old-time roentgenoscope and keeping the roentgen-ray beam small enough to give fair definition of the part under examination, one would be unlikely to expose more than the face and neck in the direct beam.

Fig. 4. Three fields exposed at one time to unfiltered roentgen rays generated at 80 kv.p.: proximal field covered by one of the gloves, middle field uncovered, and distal field covered by strip of aluminum 0.5 mm. thick. Proximal and middle fields display approximately equal degrees of reaction. Photograph made during second wave, or true erythema. The leather glove again appears to be of negligible protective value.

It is well known that many of the pioneers in roentgenology sustained injury to the hands, and occasionally to the face, by the practice of testing the hardness of the roentgen-ray tube by visualizing the bones

of the hand through a roentgenoscope. Viewed in the light of modern knowledge it is apparent that the physical characteristics of the roentgen-ray beam in use in the early days were such as to assure maximal absorption in the upper layers of tissue, since the roentgen rays were developed at a low potential and not filtered, and the hand was usually held very near the roentgen-ray tube. Furthermore, the old-time roentgenoscope rarely incorporated a protecting lead-glass in its construction, and was usually of such small size that it was quite impossible to expose the wrist in visualizing of the bones of the fingers or hand. Therefore, many reservations must be adopted when applying the experience of the old days to modern roentgenoscopic technique.

We now come to a consideration of the dosage received by the group of physicians engaged for varying periods in the Section on Roentgenology. With one exception, Carman, these men are all alive and apparently unaffected by the rays today. Up to the time of his death, in 1926, Carman gave no evidence of injury from irradiation.

As criteria of injury to the men in whom we are interested, we considered the following: (1) Local symptoms. These would include slight changes in the sensation of the finger tips, such as anesthesia or paresthesia, increased or perverted sensitivity to heat or cold, tingling or prickling sensations, and so forth. (2) Local signs. These would be changes in the skin of the fingers, hands or face; atrophy or dryness of the skin; changes in the rate of growth of hair; ridges or curvatures in the nails, brittleness of the nails; redness or shininess of the skin about the nails, piling up of skin under or about the nails, thickening of the skin of the finger tips, changes in the cutaneous pattern of the finger tips, susceptibility to hang nails. (3) Constitutional symptoms. These would comprise unwarranted feelings of fatigue or lassitude, vague gastrointestinal symptoms, or changes in sexual function. (4) Constitutional signs. We looked up the blood counts and blood pressure of these men. We did not formally investigate sterility, since we consider the blood picture to be equally informative. However, one of the men in the section became the father of a healthy baby within the last two years. Such marked local changes as roentgenologist's nails, pigmentation, and hyperkeratosis did not occur, and therefore do not require consideration. In summary, it might be said that not one of these men revealed any evidence of injury from roentgen rays.

We feel very strongly that absence of detectable injury at any time should not be considered conclusive evidence that injury has not taken place. As time passes, reports of delayed reactions (usually following treatment) appear in greater numbers in the literature. We merely emphasize that, to the present, these men have not given evidence of injury.

As has been stated, protective gloves and aprons were used intermittently in the department until 1918, when they were finally abandoned. During the fifteen years from 1918 to 1932, inclusive, the actual procedure of screening in the section has changed little, except probably to increase considerably the speed of the individual examination; moreover, a record of the number of examinations made each year is available. During this period 184,079 gastric examinations were made; the yearly average is 12,272, with a high number of 16,138 and a low number of 7,524 examinations each year. Over the five-year period, from 1927 to 1931, inclusive, the number of examinations made each month of the year is available. The smallest number of patients examined during any one month was 862 and the largest was 1,836. The average for the peak month was 1,694, and the average for the month in which the minimal number of examinations was made was 895.

No detailed record of the number of patients examined by each individual physician for this period is available. However, by reviewing carefully the records of the department, we believe we have been able

to estimate, within a limit of error of 2,000, the total number of patients examined by each man. We will consider only the three men who have examined the most patients; these we will call Doctors A, B, and C.

Dr. A made approximately 49,234 roentgen examinations of the stomach in a period of eight years. If the duration of exposure received at each examination is considered to be one and one-half minutes, as has been estimated elsewhere in this paper, and if our calculations are based on the photographic measurement of dosage to Dr. C's palm, the following values are reached: gross exposure 1.47 S.E.D., peak year 26.47 per cent S.E.D., average year 18.47 per cent S.E.D. The number of patients Dr. A examined during the individual months of this period is not known exactly, but it probably corresponds closely with the number examined by Dr. B and Dr. C. On the basis of ionization measurements, using 4 ma. tube current, Dr. A received a gross exposure on the palm of 7.32 S.E.D., a peak year exposure of 1.29 S.E.D., a slack year dose of 56.1 per cent S.E.D., and an average year dose of 90.5 per cent S.E.D.

Dr. B made approximately 41,255 roentgen examinations of the stomach in a period of eight years. Using Dr. C as a basis of photographic measurement, he received on his palm a gross exposure of 1.26 S.E.D., a peak year dose of 21.4 per cent S.E.D., a slack year of 6 per cent S.E.D., and an average year dose of 16.75 per cent S.E.D. Estimating the dose on the palm on the basis of ionization measurements with 4 ma. tube current he received a gross exposure of 5.0 S.E.D., peak year 1.05 S.E.D., slack year 29.4 per cent S.E.D., average year 76.8 per cent S.E.D.

Dr. C made approximately 42,500 roentgen examinations of the stomach in a period of seven years. On the basis of photographic measurements his palm received 1.24 S.E.D. gross exposure, a peak year dose of 30 per cent S.E.D., a slack year of 9 per cent S.E.D., and an average year dose of 17.7 per cent S.E.D. We are able to go into greater detail about him, because the number of examinations made each month has been recorded over most of this period. The monthly distribution of cases as well as their number has been very constant over this entire period, so that the following measurements probably will apply as well for Dr. A and Dr. B as for Dr. C, on whose experience they are based. An assumption of 900 patients examined during the peak month and 3,000 patients examined during the rush season is conservative for the peak years of these three men. An assumption of 600 patients for the slack months is equally conservative. The dosage received by the palm, as measured photographically for Dr. C, amounts to 2.7 per cent S.E.D. for the peak month, 9 per cent S.E.D. for the rush month and 1.8 per cent S.E.D. for the slack month. It was not unusual for Dr. C and Dr. B to examine fifty patients or more in an afternoon, resulting in a palmar dose (measured photographically) of 0.15 per cent S.E.D. On the basis of 300 working days a year, Dr. A received an average daily dose of 0.066 per cent S.E.D., Dr. B received a daily dose of 0.051 per cent S.E.D., and Dr. C received an average daily dose of 0.057 per cent S.E.D.

Based on Mutscheller's estimate of 0.2 r (or 0.033 per cent S.E.D.) as the "tolerance dose," this amounts to a daily exposure over the entire period of service of Dr. A of just twice this widely accepted tolerance dose. Based on Barclay's estimate of 0.028 per cent S.E.D. as the daily tolerance dose, the exposure of Dr. A becomes even more unsafe, for on a peak day of fifty examinations each man receives approximately five such tolerance doses. Allowing for maximal errors in our measurement, this is still a very formidable dose if we are to accept these tolerance doses as the basis of our estimate.

On the basis of ionization measurements these doses become 13.2 per cent S.E.D. for the peak month, 44.1 per cent S.E.D. for the rush season, and 8.8 per cent S.E.D. for the slack month. On a peak day of fifty

examinations, the dosage received is 0.73 per cent S.E.D. Therefore, the average daily dose becomes 0.30 per cent S.E.D. for Dr. A, 0.25 per cent S.E.D. a day for Dr. B, and 0.29 per cent S.E.D. a day for Dr. C.

On the basis of Barclay's tolerance dose this is about twenty-six tolerance doses for a peak day, and about ten tolerance doses for the average day of each man's work at the clinic. These calculations are based on our conception of 400 r as an S.E.D.

Our photographic measurements of the daily dose to the palm of 66.10^{-5}, 57.10^{-5} and 57.10^{-5} fall much nearer the average proposed tolerance dose of Barclay and of Mutscheller than that of Solomon. On the basis of our ionization chamber calculations of 0.0030 S.E.D., 0.0025 S.E.D., and 0.0029 S.E.D., the dose received by the men at the clinic is somewhat less than Solomon's estimated dose of 0.0033 S.E.D. and less than half the dose (0.007 S.E.D.) to which Barclay's workers were subjected. We were of course unable to measure finger tip dosage directly, but from our phantom work we estimate that the finger tips should be exposed to three and five-tenths times the dose received by the palm. On this basis, measured photographically, these men received 23.10^{-4}, 18.10^{-4} and 20.10^{-4} S.E.D. a day. This is less than Solomon's estimated tolerance dose, and approximately the dose known to be received in Barclay's second cited case. On the basis of our photographic measurements during the average daily session of gastric roentgenoscopy, the men exposed their palms to 2+ Barclay tolerance doses and the finger tips to 7+ tolerance doses without any apparent ill effect whatever. We therefore feel, from a review of the literature and our experimental data, that the tolerance doses proposed by Barclay and Cox, Mutscheller, Behnken, Glocker and Sievert are conservative when applied to the roentgenoscopic techniques described here.

Because there is general disagreement as to the method by which roentgen-ray doses of the type under consideration shall be measured, and since both methods used in this study have considerable inherent error, we do not advocate either method to the exclusion of the other.

Although the recommendations of the International Safety Committee seem excessive in some cases, we believe that they should be observed generally as a means of precaution until further study of the limits of safe dosage indicates change. In line with this belief, the roentgenoscopists of the clinic are arranging to employ gloves and aprons of a specially constructed fabric containing the equivalent of 0.10 mm. of lead, in order further to protect themselves from the potential biological effects of stray radiation, even though from this study these effects appear to be negligible.

SUMMARY

The roentgenscopic technique used at The Mayo Clinic, in which speed of examination, the smallest effective beam, and the protective effect of the barium-filled viscus are utilized to the fullest extent, is described. Three physicians who have employed this procedure, and have each made approximately 40,000 gastric examinations, have not shown the slightest evidence of injury from the roentgen rays. An ionization and a photographic system of measuring the doses led to results which cannot be reconciled with each other, due probably to inherent error in both systems. Both indicated that the examiners received far in excess of the accepted tolerance dose, not only in the aggregate, but also daily. Notwithstanding these facts, we feel very strongly that absence of detectable injury at any time should not be considered conclusive evidence that injury has not taken place, and we advise emphatically that roentgenologists continue to observe the recommendations of the International Safety Committee.

Vol. XXXII, No. 3

ROENTGEN-RAY DIFFRACTION STUDIES OF ENAMEL AND DENTINE

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INTRODUCTION

USING roentgen-ray diffraction methods a number of compounds, mostly of the apatite series, have been found by various investigators to be the principal constituent of the inorganic part of tooth and bone substance. Gross[1] (1926) finds that apatite, dentine and enamel give completely comparable patterns. DeJong[2] (1926) names fluorapatite as the sole constituent. Taylor and Sheard[3] (1929) give the formula $3Ca_3(PO_4)_2 \cdot CaX_2$. Cape and Kitchen[4] (1930) describe the principal constituent as "apatite." Roseberry, Hastings and Morse[5] (1931) find that most of the lines of dahllite are similar in position and in intensity to those of the diffraction pattern of bone and tooth substance, and proposed the formula $CaCO_3 \cdot nCa_3(PO_4)_2$ where $2 < n < 3$. Hendricks, Hill, Jacob and Jefferson[6] (1931) give as alternative formulae the following: $Ca_{10}CO_3(PO_4)_6$ and $Ca_{10}CO_3(PO_4)_6 \cdot H_2O$. Hendricks, Jefferson and Mosley[7] (1932) offer the following formula: $Ca_9(H_2O)_2(PO_4)_6$. Thewlis[8] (1932) finds for tooth substance an exact correspondence with the apatite structure described by St. Naray-Szabo.[12] Henschen, Straumann and Bucher[9] (1932) find tricalcium phosphate and calcium carbonate to be the principal inorganic constituents of bone. Klement and Trömel[10] (1932) and also Bredig[11] (1933) conclude that the principal constituent of bone and tooth substance is hydroxylapatite.

The nature of the minor constituents of bone and tooth substance has been the subject of more contention and disagreement than is the case for the main constituent. The chemical findings of many substances in small amounts may be explained in a satisfactory fashion by noting the many opportunities for isomorphous replacements in the complicated apatite structure.[7] Some investigators state that there are no other constituents present than apatite,[2,6,8,10,11] while others propose small amounts of magnesium or alkali salts[3,9] or of calcium carbonate,[9] although by some the latter is found absent.[5,11] Water of hydration is suggested[7] as a part of the lattice of tooth substance. CO_2 is found not to be an isomorphous replacement.[1,11]

A diversity of opinion is found on the subject of the orientation of the crystalline constituents of bone and tooth substance. Although random orientation of both enamel and dentine is reported,[5] many investigators find dentine to be randomly oriented,[1,8] while the crystal particles of enamel are preferentially oriented[1,4,8] with a small angle between the c-axes of the crystals and the long axes of the enamel rods.[1,8] Henschen, Straumann and Bucher[9] report the presence in bone of two organic lattices whose geometry includes a long axis with a slowly rising, coiled helix around it. They also show diffraction patterns from decalcified bone, which they suggest show a larger structure parallel to the long axis of the bone. As to inorganic lattices, they believe no orientation exists, the inorganic crystals fitting into the organic lattice.

The size of the individual crystal has been the subject of some study. The crystals in bone and tooth substance are very small, only a few hundred molecules to a crystal.[1,2] Incineration results in sharper lines in the diffraction pattern.[2,11] St. Naray-Szabo[12] finds that apatite is a hexagonal crystal belonging to space-group

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C_{6h}^2, and that the lattice constants are a = 9.37Å, c = 6.88Å, which is found exactly to fit tooth substance.[8] Roseberry, Hastings and Morse[5] propose a unit cell on the basis of a closely packed hexagonal lattice which, when referred to the orthorhombic axes, has the lattice constants: a = 20.8Å, b = 12.0Å, c = 8.82Å. Hendricks, Hill, Jacob and Jefferson[6] note (*a*) a broadening of the diffraction maxima in naphtha-extracted bone, (*b*) an increasing particle size on prolonged steaming, and (*c*) a mass of 1030 associated with the unit structure for naphtha-extracted bone.

A number of other facts have been reported by various observers. Modern and fossil bones give similar diffraction patterns.[2] The dentine of a tooth which had borne a gold filling for ten years shows gold lines in the diffraction pattern.[1] Similar diffraction patterns for apatite, enamel, bone, salivary calculus, a tuberculous calcification of the lung, and precipitated tricalcium phosphate are reported,[3] and other investigators find the same pattern for young and old, fresh and ashed bone, enamel, dentine, chlor- and fluorapatites, dahllite and tricalcium phosphate.[5] The absence of free lime in bone heated to 900°C. is noted.[6] The disappearance of a dominant organic structure which is found in patterns of young bone, and the appearance of an inorganic structure with increasing age is suggested.[9]

EXPERIMENTAL PROCEDURE

Most of the diffraction patterns in the experimental work reported below are made with the General Electric roentgen-ray diffraction apparatus, Type YWC, Form D.[13] Mo Kα radiation made approximately monochromatic with zirconium oxide filters is used. Two types of diffraction pictures are made: (*a*) the usual type of monochromatic powder photographs for which the apparatus is especially designed, using the regular General Electric powder diffraction cassettes, and (*b*) monochromatic pinhole pictures, using a fine beam of roentgen rays passing through a slab or flat specimen of the object examined and striking a flat film placed at a distance of about 8 cm. from the object examined. A small, 1 cm.^{2}, lead block is placed at the film to intercept the direct beam of roentgen rays and prevent fogging of the film by radiation scattered as the intense, direct roentgen rays strike the film.

Removable, brass plates backed by lead with a 1 mm. hole in the center to allow the passage of the roentgen beam, made so as to be easily attached to the pinhole system, are used as holders for the samples being studied. A ruled system of coordinates on the plate aids in orienting the material being studied. This plate also reduces scattering from the outer edges of the pinhole system proper, and makes it possible to study the diffraction pattern at very small angles, such as 4 and 5 degrees.

Exposure times of 24 to 48 hours, milliamperages of about 25 at 33 peak kilovoltage are used. Photographs herein reproduced are made by 48-hour exposures. Standard roentgen technique is used for development.

Measurements of the diffraction angles and comparisons with the theoretical placings[12] are used to determine the identity of the various diffraction rings.

The pinhole diffraction method lends itself particularly to the study of sections of dentine, enamel, bone and other tissues. Very small cross sections of any specimen may be studied, and thus it is possible to study the variation in tooth structure in various parts of the same tooth. This method also is well adapted to the study of crystal and molecular orientation in a substance, and to the study of diffraction at small angles, much smaller than can be observed on the ordinary powder photograph.

It is proposed to use this method, first, for the study of the orientation and structure of enamel and dentine of teeth, second, for the study of the variation in structure in different parts of the tooth, and third, for the study of the variation in structure from one tooth to another.

Pinhole diffraction photographs are obtained of various areas of nineteen tooth sections, and also of bone and various minerals of the apatite group. In addition, regular powder diffraction photographs of powdered dentine and enamel, bone, and some of the apatite minerals are made.

Sections about 1 mm. thick from teeth whose complete histories are known are used. The tooth slabs are obtained by slicing a tooth longitudinally through its center by means of two parallel corundum-vulcanite discs. Photo-

micrographs by transmitted light of these tooth sections are used to show the areas of enamel and normal, transparent and opaque dentine (see Figs. 2, 3 and 4), thereby permitting accurate knowledge of the exact nature of the tooth substance of which the diffraction picture is made. At least four diffraction pictures are made in each area of each tooth studied, several days elapsing between pictures. No effort is made to prevent the tooth slabs from drying in the air during exposure to roentgen rays. However, the slabs are kept in tap water until used and between exposures.

axis of most of the enamel rods. All of the interference maxima show evidence of preferential orientation; thus a definite crystal orientation is demonstrated. The orientation is shown by the non-homogenous distribution in the diffraction cones for (002) and (004) (Figs. 1, B′ and B″). The length of arcs for these planes indicates that the c-axes of the minute, individual crystals making up the inorganic portion of the enamel are distributed over a region of about 60° in a plane normal to the roentgen beam. The intensities of the arcs produced by these planes (002) and (004) are not equal on op-

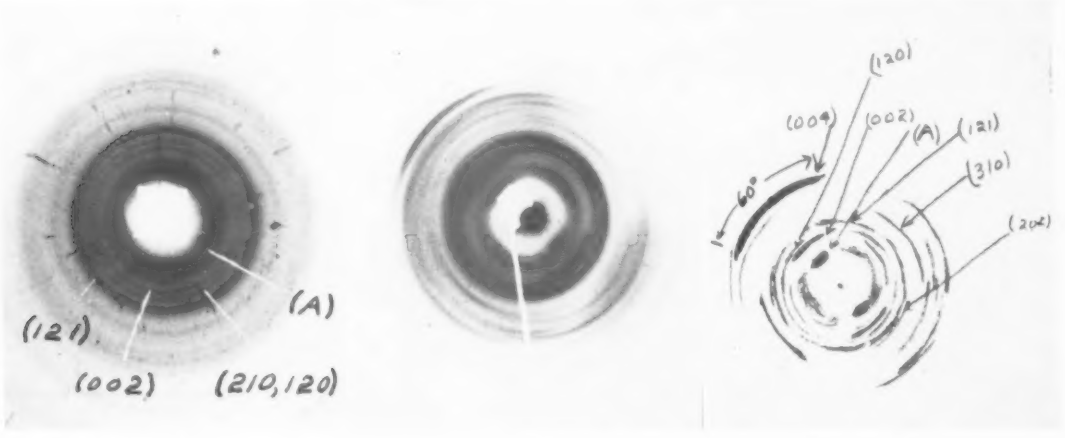

Fig. 1. A′, pinhole diffraction pattern of fluorapatite, (A) refers to the broad, inner, diffuse ring. Note relative transparency of center. The speckled appearance is due to the relatively gross particle size. B′, pinhole diffraction photograph of enamel taken at nearly right angles to the long axis of the enamel rods. Note transparency of center. Preferential orientation is evidenced by the presence of intensified arcs in the diffraction rings. B″, drawing of enamel diffraction pattern shown in B′, with the identity of the planes producing the principal diffraction maxima indicated.

DATA

Figure 1, A′ shows a monochromatic pinhole powder diffraction picture of fluorapatite. The picture is a typical apatite diffraction pattern. The broad, inner, diffuse ring indicated by (A) has not been previously noted. The center is relatively transparent. The (002) ring is slightly less prominent than the (210, 120) ring. The relative coarseness of the apatite particles is evidenced by the speckled appearance of the rings.

A monochromatic pinhole diffraction picture of enamel is shown in Figure 1, B′, and a drawing indicating the more prominent arcs is shown in Figure 1, B″. Microscopical study of the tooth slab indicates that the direction of the roentgen beam is perpendicular to the long

posite sides of the photograph, which indicates that there is a distribution of the c-axes about, in contradistinction to within, the plane normal to the roentgen beam. A study of this and other diffraction photographs of enamel shows that this distribution, too, covers about 60°. The conclusion is that all of the c-axes of the minute crystals making up the enamel rods lie in a cone with a 60° vertical angle, the axes of the cone being the mean axis of crystal orientation. Furthermore, the mean axis of crystal orientation has a direction toward the tip of the tooth about 20° from the normal to the tooth. This confirms the results of Thewlis.[8] The angle of crystal orientation has an inclination averaging 15° to the long axes of the enamel rods; thus the hexagonal crystals of the enamel substance do not determine the form of the rods.

A photomicrograph of tooth slab No. 100 from an upper right second bicuspid (Fig. 2, P 1) shows the areas chosen for roentgen study in normal, transparent and opaque dentine. Monochromatic, pinhole diffraction pictures of the respective areas are shown in Figure 2, A′ through normal, B′ through transparent and C′ through opaque dentine. These all give a typical apatite pattern. The broad, inner, diffuse ring is present, although not so evident as in the apatite and enamel pictures. The center is relatively not so transparent as in apatite and enamel pictures. In each picture the (002) ring is more intense than the (210, 120) ring. In general, the patterns from the different kinds of dentine of tooth No. 100 are identical.

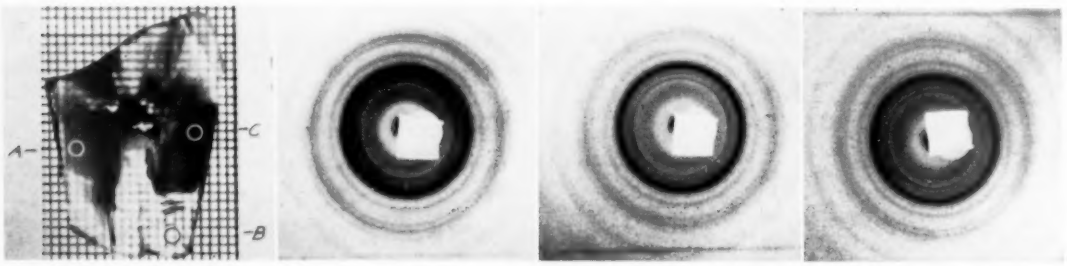

FIG. 2. P 1, photomicrograph of slab of tooth No. 100 with areas of A—normal, B—transparent, C—opaque dentine indicated. A′, B′, and C′ are pinhole diffraction patterns through areas A, B, and C of P1. Note relative transparency of center, and broad, inner, diffuse ring similar to Figure 1, A′ and B′. The (002) rings appear more intense than the (210, 120) rings.

A photomicrograph of the tooth slab No. 80 (Fig. 3, P 2) from an upper right central incisor shows the areas chosen for roentgen study in normal, transparent and opaque dentine. Monochromatic pinhole diffraction pictures of the respective areas are shown in Figure 3, A′ through normal, B′ through transparent and C′ through opaque dentine. These all give a typical apatite pattern. The broad, inner, diffuse ring and the transparency of the center are similar to the same phenomena in the pictures of tooth No. 100. In each picture the (002) ring is of about the same intensity as the (210, 120) ring. In general, the patterns from the different kinds of dentine of tooth No. 80 are identical.

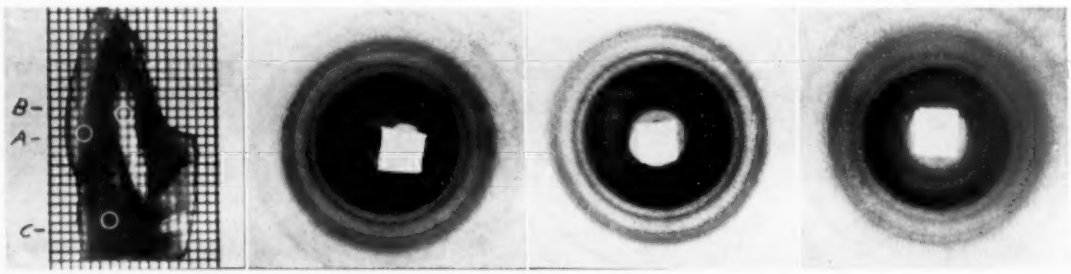

FIG. 3. P 2, photomicrograph of cross section of tooth No. 80, with areas of A—normal, B—transparent, and C—opaque dentine whose diffraction patterns are shown at the right in A′, B′ and C′, respectively. Note general similarity to tooth No. 100 except the (002) rings appear of equal intensity to the (210, 120) rings.

A photomicrograph of tooth slab No. 64 (Fig. 4, P 3) from a mandibular left central incisor shows the areas chosen for roentgen study in normal, transparent, and opaque dentine. Monochromatic pinhole diffraction pictures of the respective areas are shown in Figure 4, A′ through normal, B′ through transparent and C′ through opaque dentine. The diffraction pictures are in most respects like those of tooth No. 100 and tooth No. 80, except that in each picture of tooth No. 64 the (002) ring is less

intense than the (210, 120) ring. In general, the patterns from the different kinds of dentine of tooth No. 64 are identical.

Comparing the types of diffraction pictures obtained from the three teeth, Nos. 100, 80, and 64, it is apparent that the relative intensity of the (002) and the (210, 120) diffraction rings seems to be a characteristic of the tooth and not of the type of dentine. The study of 19 teeth in which at least four and as high as ten pictures are made of each tooth section seems to demonstrate that this is always the case. Of these 19 teeth, 14 show the inner (002) diffraction ring stronger than the (210, 120) diffraction ring, 3 tooth sections show these two rings of about the same intensity, while 2 teeth show the outer (210, 120) ring definitely stronger than the inner (002) diffraction ring.

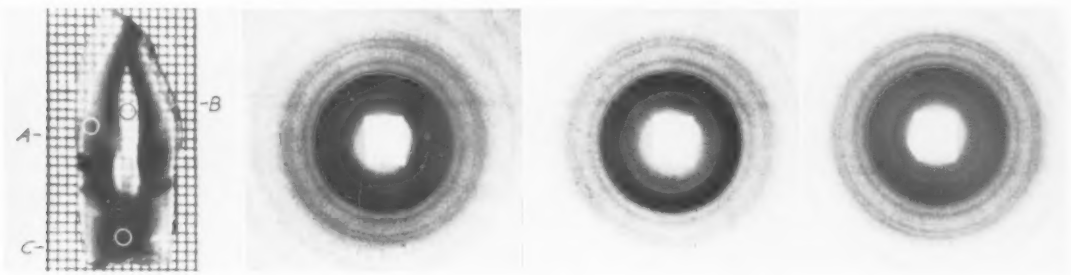

FIG. 4. P 3, photomicrograph of slab of tooth No. 64 with areas of A—normal, B—transparent and C—opaque dentine whose diffraction patterns are shown at the right in A′, B′ and C′, respectively. Note general similarity to teeth Nos. 100 and 80 except the (002) rings appear less intense than the (210, 120) rings.

Using the regular General Electric powder diffraction cassettes, powder diffraction pictures were made of powdered enamel, powdered dentine, and of various minerals of the apatite family, including fluorapatite, chlorapatite, monite, collophanite, pebble rock phosphate, and staffelite. These powder diffraction photographs are all similar. Every one of the 38 diffraction lines that are measured in enamel are found to be present in the same apparent position and approximately the same intensity in each of the natural minerals examined. The diffraction photographs of powdered dentine show a much denser general scattering than in enamel. This scattering apparently obscures some of the fainter dentine diffraction maxima. Every diffraction line visible in dentine, 25 in number, corresponds exactly, both in position and relative intensity, with a line of the enamel diffraction pattern. The dentine lines appear broader and more diffuse than the enamel diffraction lines. In order to obtain powder photographs for enamel and dentine for comparison with more nearly the same background conditions, starch is mixed with powdered enamel in approximately the same proportion as the organic material present in dentine. With a background of about the same intensity of general scattering, the crystal diffraction lines in dentine, of the same intensity as those in enamel, tend to be broader and more diffuse than those of enamel. The fainter lines of enamel do not appear in dentine at all, even though the (121) line, the strongest diffraction line, is stronger in the dentine than in the enamel-starch photograph. This indicates that the individual crystalline particles of dentine are much smaller than enamel, so small that the resolution of the diffraction pattern is poor and the lines thus broadened.

Calculations, using the method of Sheerer[14] based on the increased width of the diffraction bands due to small crystal size, give as the approximate size of the average dentine crystal the order of 2.4×10^{-6} cm. By the same method the mean enamel crystal size is found to be of the order of 2.7×10^{-5} cm.

DISCUSSION

Comparison powder photographs of dentine, enamel, and various apatite minerals indicate that there is no crystalline constituent, either inorganic or organic, present in dentine that is not also present in enamel, and that the crystalline constituent of both is an apatite type of mineral. These data confirm the work of Roseberry, Hastings and Morse insofar as they find evidence only of an apatite-type mineral

present, and the statement of Thewlis that "no X-ray reflexions are observed which cannot be ascribed to apatite."

The broad, diffuse, inner ring which has been shown inside the (002) ring in enamel and less clearly in dentine may be attributed to an inorganic constituent since it is also present in apatite (Fig. 1, A'). Preferential orientation of the inner diffraction ring in enamel indicated by (A) on Figure 1, B'' shows orientation similar to (002). This ring corresponds to the "striking inner broad diffraction ring" described in bone by Clark, Bucher and Lorenz and to the "breiten unscharfen Ring" of Henschen, Straumann and Bucher, both of whom attribute its presence to the organic constituents. This diffraction ring, although produced by apatite, is not readily identified, for it does not seem to correspond to any calculated apatite maxima. It is due to scattering at so small an angle that it has probably never been observed before in apatite.

There is no evidence for the presence of crystalline calcium carbonate or trimagnesium phosphate in tooth substance, contrary to the statements of Henschen et al[9] concerning the composition of bone. There is a very large amount of diffuse scattering in dentine, compared with enamel, which indicates that the additional organic matter present in dentine is probably not of crystalline nature, or if crystalline is colloidal in nature, randomly oriented. The observations recorded above that the orientation in enamel is preferential and in dentine random confirm the work of Cape and Kitchen, and Thewlis, but are contrary to the conclusions of Roseberry, Hastings and Morse. The inability of the latter investigators to find any evidence of orientation in enamel may have been due to the possibility that the direction of the roentgen beam was normal to the surface of the enamel, since the enamel orientation should be nearly random around this axis. A specimen of staffelite, a member of the apatite group, selected because it resembled enamel very much in macroscopic appearance, shows from a pinhole diffraction photograph an orientation of crystal constituents very similar to that of enamel, suggesting that it may be possible to reproduce experimentally the conditions under which enamel is formed.

Since the unit cell for fluorapatite found by St. Naray-Szabo is nearly identical with that found for other members of the apatite family by other investigators,[6,7] and since it also accounts satisfactorily for all the lines in the enamel and dentine diffraction photographs, it is probable that this is also the correct unit cell for enamel and dentine. The unit cell proposed by Roseberry, Hastings and Morse does not correspond to any unit cell found by others[6,7,12] for any of the apatite group of minerals. All of the natural apatite minerals have crystal lattices that produce very similar roentgen-ray diffraction patterns, indicating that they have closely similar unit cells and a somewhat uniform plan of atomic arrangement inside the unit cell. Also, since the intensities of the various lines in the diffraction patterns of enamel and dentine are so closely similar to those of the various apatites, the general plan of atomic arrangement inside the unit cell must be similar. Although the evidence offered indicates that the mineral constituents of teeth are related to the apatite series of minerals, this cannot be taken to indicate necessarily an invariable chemical composition, since there are almost limitless possibilities of isomorphous replacement. It is possible from crystallographic considerations that the crystalline constitution of enamel and dentine is not entirely uniform and may vary considerably from person to person, and even from one part of the tooth to another, and still not be perceptible in appearance or even in such crystal diffraction photographs as have hitherto been made.

The variation in the relative intensities of the (002) and the (210, 120) rings in dentine of different teeth is of doubtful meaning, but may be attributed to the variation in the dimensions of the dentine

crystals or to the variation in the chemical composition. It is noted that most of the fainter lines are absent on the dentine powder photographs, which with the greater line breadth observed is due to the very small size of the individual mineral crystals in dentine. The relative intensities of the diffraction rings for substances composed of very small crystals should depend on the extension of single crystals in the direction of the planes producing these rings. Thus, elongation in the direction of "c" without accompanying increase in cross section would lead to a relative enhancement of the ring produced by the (210, 120) planes which are parallel to "c." The principal constituent of tooth substance has been suggested by Hendricks et al[6] to be a carbonate apatite. Since the (002) ring has the higher calculated intensity for carbonate apatite, the intensifications of the (210, 120) ring noted may indicate an elongation along the c-axis of the dentine particles in some of the tooth sections.[17]

Taylor and Sheard suggest that differences in the X_2 substituent of $3Ca_3(PO_4)_2 \cdot CaX_2$ may be responsible for variations in the positions and intensities of the various diffraction maxima. Relatively small differences in chemical composition of calcium phosphates are shown by Schleede, Schmidt and Kindt[15] to give variations in the relative intensities of what are apparently the (002) and (210, 120) lines. Because the chemical composition of the tooth substance is well known to be relatively invariable,[16] the relation of chemical composition to the relative intensities of these rings may well offer opportunity for profitable investigation.

CONCLUSIONS

1. The crystalline constituents of tooth substance, enamel or dentine, give apatite-like diffraction patterns with monochromatic roentgen-ray radiation. There is no evidence of any other type of crystalline material present.

2. Roentgen-ray diffraction studies of apatite minerals show a broad, inner, diffuse ring not hitherto reported. This broad diffraction ring seems to correspond to similar rings reported by others in bone, and attributed by them to its organic constituents.

3. Roentgen-ray diffraction patterns of enamel exhibit evidences of a preferential orientation. The c-axes of the crystals lie in a cone with a 60° vertical angle, the axis of the cone being the mean axis of crystal orientation. The average angle of crystal orientation is about 15° toward the tooth tip from the long axis of the enamel rod. The shape of an enamel rod appears not to depend on the shape of the individual minute crystals contained in it.

4. Normal, transparent and opaque dentine from the same tooth have identical roentgen-ray diffraction patterns.

5. In the roentgen-ray diffraction pictures of dentine the relative intensities of the (002) and (210, 120) rings may vary from tooth to tooth. Of the 19 teeth studied, 14 show the (002) diffraction ring to be stronger than the (210, 120) ring, 3 show the rings of about equal intensity, and 2 show the (102, 120) ring to be the more intense.

6. The mean crystal size is calculated to be 2.7×10^{-5} cm. in enamel and 2.4×10^{-6} cm. in dentine.

We wish to express our indebtedness to F. W. Bishop, Associate in Radiology; to Professors T.R. Wilkins, F. C. Fairbanks, Scott Smith, and Mr. F. Baumgartner, of the Department of Physics of the University of Rochester; and to R. B. Wilsey and G. Silberstein of the Research Laboratory of the Eastman Kodak Company.

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STUDIES ON THE EFFECT OF ROENTGEN RAYS ON LYMPHOMATOSIS OF MICE*

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IN THIS paper we shall describe experiments made in attempts to determine the best conditions for irradiation with roentgen rays in the treatment of leucemia in mice.

In a previous paper† we reported observations showing that irradiation of the entire body of lymphomatous mice with sublethal doses of roentgen rays does not prevent the fatal termination of the disease but prolongs life, probably by destruction of some malignant lymphocytes. Only two transmissible strains of leucemia were studied and the mice were irradiated a few hours after inoculation and, in two experiments, one day after inoculation.

It seemed, therefore, desirable to determine whether other strains of lymphomatosis behave similarly, whether life is prolonged further by irradiation later than one day after inoculation, whether fractional irradiation is more beneficial than a single large dose, and in what way the dose is related to the prolongation of life.

Lymphomatosis was produced in the mice by transmission. Four of the five transmissible strains used and the methods of transfer and irradiation have been described in our previous report.

Members of a stock of mice susceptible to a given strain will be spoken of as susceptible mice, others as resistant mice. In therapeutic studies it is advisable to work with susceptible, preferably with inbred animals only. The difference in behavior between resistant and susceptible mice is shown in Table 1. The experiments recorded in this table compare the effect of roentgen rays applied immediately before, immediately after, and one and three days after inoculation. Each experiment was made with the same suspension of malignant lymphocytes, and irradiation of the groups of mice inoculated immediately before and immediately after irradiation was simultaneous.

The suspension of malignant lymphocytes was chilled and part of it was injected into the tail veins of one group of mice while the rest of the suspension was kept on ice. The second group was injected immediately after irradiation. Previous experiments have shown that chilled leucemic lymphocytes undergo practically no deterioration within a few hours.

Irradiation of susceptible mice immediately before and immediately after inoculation shortened somewhat the life of the animals inoculated with Strain Rg 10 as compared with the unirradiated controls, but irradiation one and three days after inoculation prolonged life (Table 1). Prolongation of life was greater when irradiation was made three days than when it was made one day after inoculation. Resistant non-irradiated mice inoculated at the same time with the same material remained free from lymphomatosis. Resistant mice irradiated three days after injection also remained free from lymphomatosis. The mice irradiated after inoculation lived longer than those irradiated before inoculation. Experiments like those just described led us to suppose that irradiation after inoculation prolongs the life of inoculated animals. When mice were irradiated immediately before and immediately after injection (Table 1) with the same quantity of roentgen rays, the same degree of roentgen injuries was received by all irradiated animals. Prolongation of life of mice irradiated after inoculation was, therefore, due to the direct effect of the

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† Furth, J., Seibold, H. R., and Rathbone, R. R. Experimental studies on lymphomatosis of mice. *Am. J. Cancer*, 1933, *19*, 521–604.

TABLE I

ROENTGEN IRRADIATION WITH 400 r OF THE ENTIRE BODY OF MICE INOCULATED WITH STRAIN Rg 10

Time of irradiation	No. of mice			No. died of intercurrent disease	Average length of life*
	Injected	+	−		
Experiment 1a. Susceptible mice:					*days*
Immediately before inoculation	5	5			13.6
Immediately after inoculation	5	4		1	18
1 day after inoculation	5	5			23.4
3 days after inoculation	5	5			29
Control (not irradiated)	5	4		1	22.5
Experiment 1b. Resistant mice:					
Immediately before irradiation	4	4			16.5
Immediately after irradiation	5	1	1	3	20
1 day after irradiation	5	1	1	3	21
3 days after irradiation	4		4		
Control (not irradiated)	5		5		
Experiment 2. Resistant mice:					
3 days before inoculation	5	3	1	1	19.3
Immediately before inoculation	5	5			18.6
Immediately after inoculation	5	5			20.8
1 day after inoculation	5	4		1	24

Abbreviations used in the tables. +=inoculation successful; −=inoculation unsuccessful; ±=inoculation of doubtful success.
* of lymphomatous mice after inoculation.

roentgen rays on the malignant lymphocytes introduced. Since we know from previous experiments that the length of life after inoculation is in inverse relation to the inoculating dose, it may be supposed that irradiation with roentgen rays decreased the number of viable malignant lymphocytes injected. The injurious effect of roentgen rays on the host tends to counteract the benefit of their destructive effect on the malignant lymphocytes. Roentgen rays applied before inoculation shorten the life of the animal and render resistant mice susceptible to lymphomatosis, and to some infections. A resistant host inactivates the foreign malignant lymphocytes within a few days after inoculation. The process of inactivation of malignant lymphocytes by resistant hosts apparently begins immediately after intravenous inoculation, and its rapidity depends mainly on the genetical relationship of the malignant cells to the host. Obviously, there are all degrees between highly susceptible and highly resistant mice, and experiments such as those shown in Table I are a convenient means of determining the degree of resistance of mice to a given strain. Direct tests on the rate of inactivation of malignant lymphocytes in a resistant host have not been made.

Numerous experiments made with Strain A 35 will be shown in the second part of this paper (Tables IV and V). These experiments indicate that the life of most mice following inoculation with *lymphomatosis A 35* is prolonged by irradiation with roentgen rays. In a few experiments, however, the injurious effects of roentgen rays on the host almost balanced the benefit of the destructive action on the inoculated malignant lymphocytes.

E. g., in Experiments 3 and 4 (not given in the tables) the average life of ten susceptible mice successfully inoculated with Strain A 35 was 10.7 days, of ten mice irradiated immediately before and one day before inoculation 7.7 days, of fourteen mice irradiated one and one-half, and twenty-four hours after inoculation 10.5 days, and of two mice irradiated five days after inoculation 12.5 days.

It seemed desirable to test the correctness of the conclusions reached in these

experiments with several strains. For the sake of brevity, not all experiments made will be described, but none omitted contradicts the results of those described.

In Experiments 5 to 8 (Table II), made with susceptible mice, thirteen of the seventeen non-irradiated mice inoculated with mice was accomplished partly by the host.

In Experiment 10 (Table III) ten inbred mice of family Af were injected with Strain Af 209 and all proved susceptible. The life of five of the inoculated mice was slightly prolonged by roentgen rays administered four days after inoculation, but they finally

TABLE II

THE EFFECT OF ROENTGEN IRRADIATION WITH 400 r ON MICE WITH LYMPHOMATOSIS S 27

Time of irradiation	No. of mice			No. died of intercurrent disease	Average length of life*
	Injected	+	−		
					days
Experiments 5-8. Susceptible mice:					
1 to 2 days after inoculation	17	8	7	2	10.1
Control (not irradiated)	17	13	4		9.6
Experiment 9. Resistant mice:					
Immediately before inoculation	5	5			8.5
Immediately after inoculation	5	3		2	10.3
1 day after inoculation	5	1	3	1	12
Control (not irradiated)	5		5		

* of lymphomatous mice after inoculation.

Strain S 27 developed lymphomatosis and lived for an average period of 9.6 days. Eight of the seventeen mice irradiated from one to two days after inoculation developed lymphomatosis and lived for an average period of 10.1 days. Thus in these experiments irradiation from one to two days after inoculation seems to have prevented the development of leucemia in some of the inoculated animals and the average length of life of the irradiated mice that developed leucemia was slightly longer than that of the unirradiated controls.

Experiment 9 (Table II) was made with resistant mice and shows that the percentage of successful inoculations and the length of life of the animals inoculated with Strain S 27 was greater in the group irradiated after inoculation than in that irradiated before inoculation. Since the number of successful inoculations was smaller and the duration of illness longer in mice irradiated one day after inoculation than in mice irradiated immediately after inoculation, it is evident that the destruction of malignant lymphocytes in these died of lymphomatosis. They lived for 13.2 days after inoculation; the non-irradiated control mice lived for 11.4 days.

In Experiments 11 and 12 (Table III) all non-irradiated mice used proved resistant to Strain Af 209. Most mice irradiated before inoculation developed lymphomatosis, but those irradiated one day after inoculation remained healthy. In Experiment 11 a few mice irradiated immediately after inoculation developed lymphomatosis but in Experiment 12 none did. These results may be explained by assuming either that Strain Af 209 is more susceptible to irradiation than the other strains tested or that resistant mice inactivate very rapidly the malignant cells of this strain. The former assumption is contradicted by Experiment 10, while the latter is strongly supported by Experiment 11, which shows that only three of seven mice irradiated immediately after inoculation died with lymphomatosis, and all seven mice irradiated one day after inoculation remained healthy.

In Experiment 13, Table III, *Leptospira*

TABLE III

THE EFFECT OF ROENTGEN IRRADIATION WITH 400 r ON MICE WITH LYMPHOMATOSIS Af 209

Time of irradiation	No. of mice				No. died of intercurrent disease	Average length of life*
	Injected	+	−	±		
Experiment 10:						*days*
4 days after inoculation	5	5				13.2
Control (not irradiated)	5	5				11.4
Experiment 11:						
1 day before inoculation	6	4	1		1	14.3
Immediately after inoculation	7	3	3		1	22
1 day after inoculation	7		7			
Control (not irradiated)	4		4			
Experiment 12:						
Immediately before inoculation	5	3	1		1	19.3
Immediately after inoculation	5		5			
1 day after inoculation	5	4			1	
Control (not irradiated)	5		5			
Experiment 13:						
3 days before inoculation	6	5			1	16.8
Immediately before inoculation	6	1		1	4	
Immediately after inoculation	6	3			3	26.3
1 day after inoculation	6		5		1	
Control (not irradiated)	6		3	2	1	

* of lymphomatous mice after inoculation.

contaminated the material used for inoculation. Non-irradiated mice resisted the *Leptospira* infection, but most of the mice irradiated immediately before and immediately after inoculation died of it. This experiment shows that a study of the effect of roentgen rays on lymphomatosis produced in irradiated resistant mice is complicated by factors not operating in susceptible mice. Prolongation of life after irradiation is very conspicuous in these mice but is caused only in part by roentgen rays, in part by the resistant host.

Two experiments like those described above were performed with *Strain Ar 21*. In one experiment the inoculations were made subcutaneously. In the four non-irradiated mice the tumors that developed at the site of injection regressed, in all but one of the thirteen irradiated mice they progressed, causing the death of most of the animals. The three mice irradiated after inoculation lived for an average of 20.3 days, the five mice irradiated immediately before inoculation lived for 13.8 days. In one experiment, where the inoculation was intravenous, the life of the mice was not prolonged by irradiation. Four mice irradiated immediately before inoculation lived for an average of 17.3 days and three mice irradiated immediately after inoculation lived for an average of seventeen days.

Thus only slight differences were observed in the roentgen-ray susceptibility of the five strains tested and with none of them could life be prolonged more than approximately one-half.

RELATION OF QUANTITY OF ROENTGEN RAYS TO THE DURATION OF LIFE AFTER INOCULATION

The results of four experiments, summarized in Table IV, show that prolongation of life is proportional, within certain limits, to the quantity of roentgen rays applied, and that 150 to 200 r is the smallest dose that has any favorable effect. With smaller doses single applications of roentgen rays are ineffective; 400 r had apparently the most favorable effect.

TABLE IV

THE RELATION OF THE QUANTITY OF IRRADIATION TO THE LENGTH OF LIFE OF MICE WITH LYMPHOMATOSIS (STRAIN A 35)

No. of experiments	Dose	Time of irradiation	No. of mice			Average length of life*
			injected	+	−	
	roentgens	*After inoculation*				*days*
2	450	3 days	12	10	2	10.9
3	400	2½ hours to 3 days	16	11	5	13.6
1	200	5 days	5	4	1	10
2	150	3 days	12	8	3	9.6
1	100	5 days	5	4	1	7.8
3	50	3 and 5 days	17	14	3	7.7
2	18 to 25	2½ hours and 3 days	12	9	3	8.5
		Before inoculation				
2	400	immediately and 6 days	10	10		8.5
4		*Control (not irradiated)*	22	16	5	8.6

One mouse irradiated with 150 r and one control mouse died of intercurrent disease.
* of lymphomatous mice after inoculation.

The experimental conditions for therapeutic studies were not favorable with Strain A 35. The virulence of this strain had increased in the course of repeated passages and the experiments summarized in Table IV were performed at a time when the course of the illness was rapid. Nevertheless, life was prolonged approximately one-half by the use of 400 r of roentgen rays.

THE THERAPEUTIC EFFECT OF FRACTIONAL IRRADIATION COMPARED WITH THAT OF SINGLE IRRADIATION

Although leucemia caused by transmission in mice is not a natural disease, it seems worth while to inquire what information it would yield on the much disputed problem of the relative efficiency of fractional and single irradiation. The experiments are simple, and it is probable that similar ones have been made with transmissible tumors before, but we have seen no report of them.

The results of four experiments recorded in Table V strongly suggest that a single large dose is as good as fractional irradiation.

The first three experiments shown in Table V were made with Strain A 35. In the first experiment, irradiation prolonged the life of the inoculated animals and a single dose of 400 r prolonged life further than four doses of 100 r each on four consecutive days.

In the second experiment also, both single and fractional irradiation prolonged the life of the leucemic mice. This experiment was complicated by an unidentified intercurrent disease that destroyed most of the mice exposed to a single dose of 400 r of roentgen rays.

The third experiment shown in Table V was complicated by *Leptospira* infection among the irradiated animals. Death by intercurrent disease, due to *Leptospira* infection, was greatest among mice receiving 600 r. This parasite was also seen in the blood of one mouse irradiated with 400 r, but not in the blood of control mice. This indicates the high susceptibility of irradiated mice to *Leptospira* and the resistance of non-irradiated mice to this infection.

This indication was amply confirmed by the experimental studies of Dr. Bragdon, who found that many mice are latent carriers of this infection. He

found that non-irradiated mice inoculated with *Leptospira* remained healthy, whereas irradiated mice succumbed to the infection. As described in the preceding report, another protozoon, *Erythrozoon coccoides*, had a similar effect upon mice exposed to gamma rays of radium.

The fourth part of Table v, is an experiment made with Strain Rg 10. In this experiment, too, irradiation with roentgen rays prolonged the life of the animals. Fractional irradiation was less effective than single irradiation.

These experiments show that the life of leucemic mice may be prolonged by both fractional irradiation and single irradiation and that life is prolonged further after single irradiation than after fractional irradiation, with the exception of one experiment in which most mice exposed to a single dose of roentgen rays died of an unidentified intercurrent disease.

TABLE V

THE EFFECT OF FRACTIONAL IRRADIATION COMPARED WITH THAT OF SINGLE IRRADIATION

Dose	Time of irradiation	No. of mice				No. died of intercurrent disease	Average length of life*
		Injected	+	−	±		
r							*days*
400	1 day after inoculation	10	10				11.3
4×100	1, 2, 3, 4 days after inoculation	10	9			1	9.3
	Control (not irradiated)	8	6	2			6.7
400	1 day after inoculation	10	2	1		7	11
4×100	1, 2, 3, 4 days after inoculation	10	4	6			11.8
	Control (not irradiated)	8	7		1		9.3
400	1 day after inoculation	6	5	1			11.8
600	1 day after inoculation	6	4			2	12
6×100	1, 2, 3, 4, 5, 6 days after inoculation	8	2	1		5	10.5
	Control (not irradiated)	6	5			1	9.4
400	4 days after inoculation	5	2	2		1	29
5× 80	1, 2, 3, 4, 5 days after inoculation	6	3	2		1	22.7
600	4 days after inoculation	6	2		2	2	—
5×120	1, 2, 3, 4, 5 days after inoculation	6	5			1	20
	Control (not irradiated)	7	4	2		1	15.3

* of lymphomatous mice after inoculation.

COMMENTS

Should a method of control of leucemia and allied systemic disturbances be found, it probably would act simultaneously throughout the body. The leucemic lymphocytes are malignant cells; irradiating one part of the body leaves the malignant lymphocytes unharmed in other parts of the body. If the disease is well disseminated, total irradiation is the only procedure from which complete control might be expected. This is, however, not feasible, because total irradiation with even sublethal doses does not injure or destroy all malignant lymphocytes, but it may cause fatal injuries in the host.

It is, however, possible, without fatal injury to the host, to destroy by roentgen rays some malignant lymphocytes, and

thereby prolong the life of lymphomatous mice. The experiments recorded here have shown this destruction under very adverse conditions, since virulent strains and lymphoid leucemia, which in man is known to be relatively resistant to irradiation, were used. A fairly large amount of irradiation is required to cause conspicuous prolongation of life of lymphomatous mice, and since these doses cause a more profound depression of the leucocyte count than any observed in man exposed to therapeutic doses of roentgen rays, it seems probable that the quantities of roentgen rays used in the treatment of human leucemia are below the optimal dose suggested by our work. On the other hand, the beneficial effect of very large doses of roentgen rays may be offset by lowering the resistance of the host. The mice treated with roentgen rays, however, were not under conditions that might have prevented some of the loss caused by intercurrent infections.*

* The conditions for therapeutic irradiation are favorable when the malignant proliferation of blood cells is localized to one part of the body. Experiments performed since this paper was submitted for publication have shown that a single dose of 3,000 r applied to malignant lymphomas of the leg, produced by inoculation with Strain Rg 10, is capable of bringing about complete regression of the tumor without causing fatal damage to the host. Irradiation with smaller doses (2,000 r and 1,000 r) caused only partial regression of the tumor and the animals died with generalized lymphomatosis.

CONCLUSIONS

Total irradiation by roentgen rays of lymphomatous mice prolonged their life. This effect was proportional to the quantity of roentgen rays applied.

Fractional irradiation also prolonged the life of the irradiated leucemic mice, but under the conditions prevailing in these experiments, it was not more effective than single irradiation with a correspondingly large dose.

Prolongation of life of leucemic mice by roentgen rays is due to a direct effect of the roentgen rays on the malignant lymphocytes.

Death caused by intercurrent diseases was greater among the irradiated than among the non-irradiated animals.

A SIMPLE METHOD OF PHOTOMETERING PHOTOGRAPHIC SPECTRA

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THE basic correctness and reliability of roentgen-ray voltages determined from the minimum wave length of a spectrum in contrast with the difficulties and possible errors involved in determining voltages by electrical measurements justify efforts to make the spectral or minimum wave length method of estimating high voltages sufficiently simple to be practical for use in clinical therapy laboratories. This fact is brought out more and more forcefully from quantitative measurements made on a large variety of apparatus in use in clinics, for electrically measured voltages prove to be to some extent an unreliable indication of the quality of the radiation produced.[1] The spectrum, however, indicates that particular voltage which was effective in producing roentgen rays and, being determined from the shortest wave length of the rays generated, it is free from the errors and discrepancies which may be present in the electrical methods of measuring high voltages.

An apparently simple method of evaluating spectra was described in 1928.[2] In this method, the microscope is used for matching tints. While satisfactory and useful results are obtainable by it, its application produces a considerable amount of eye strain and fatigue. Also the difficulty of exactly measuring the tints, especially as high magnification produces the appearance of a granular structure in the film, tends to make this optical method of photometry open to possible errors. The development of the light sensitive copper-oxide photovoltaic cell known under the name of "photox," has made possible a valuable simplification of the method itself and a distinct improvement in its accuracy, for which reasons it is described here.

In Figure 1, *B* is an ordinary type 100 watt incandescent lamp, and *L* is a collecting lens of about 15 cm. focal length. *S* is a slit, *F* is a film to be photometered, *C* is a light protective cardboard cylinder and *PH* is a photox cell. *G* is a measuring instrument of the galvanometer type, sensitivity about 0.5 micro-ampere per division.

The device, *S*, is similar to that described[2] except that there is only one slit and no film is required for comparison. *Sc* is a millimeter scale along which the film, *F*, is displaced a fixed distance each time, while a reading of the meter *G* is being taken in each position.

Through the lens, *L*, the projection of the filament is caused to fall upon the slit *S*. Naturally, it is necessary that the lamp, *B*, be adjusted so that the projection of the filament runs parallel with the slit and falls exactly upon it. The intensity of the light can then be regulated by placing over the lens a diaphragm, *D*, of black paper or cardboard through which the amount of light collected in the lens, *L*, can be adjusted. The distance between the lens and the slit is adjusted so that the projection of the filament is either equal to or slightly wider than the slit *S*. The distance between the slit and the photox cell is adjusted so that the projection of the light coming through the slit just covers the active surface of the photox cell. It is advisable to provide a small switch, *Sw*, to close the meter circuit for the purpose of taking a reading. Because of the very low voltages generated in the rectifying layers of copper-oxide cells (Sperrschicht),[3] it is important to select a current-measuring instrument of as low a resistance as is practical to obtain the required sensitivity. The readings are then conveniently made successively after displacing the film 0.5 mm. each time and recording the reading of the current-measuring instrument *G*. In that

fashion, spectral curves as shown in Figure 3 are obtained. It may be remarked that in many instances slight differences, as shown in Figure 3, are not or hardly at all recognizable from the spectral photographic film, but this method of photometry is capable of bringing out even very small characteristic differences.

This method of graphically evaluating the wave length intensities of roentgen-ray spectra is, of course, not an absolute method (there is actually no absolute method known that gives an absolutely true intensity spectrum of roentgen rays), and therefore its value lies in the possibility of being able to compare spectra made and interpreted under like conditions. However, it is possible to correct for the characteristics of photographic material, i.e., characteristics of photographic emulsions and intensifying screens, through the following method:

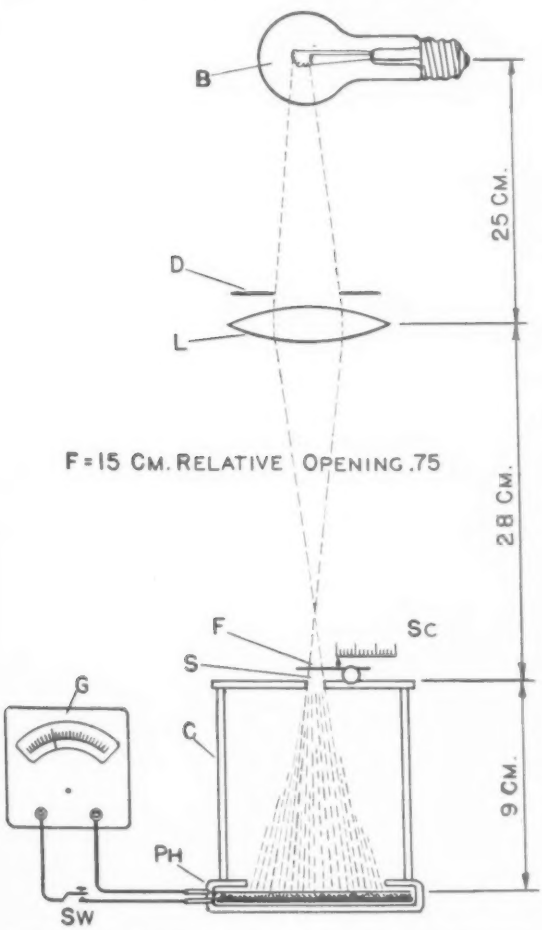

FIG. 1. Relative positions of the lamp, lens, spectrum, film and photox cell.

Figure 2 is an intensity curve obtained by exposing a photographic film (the same

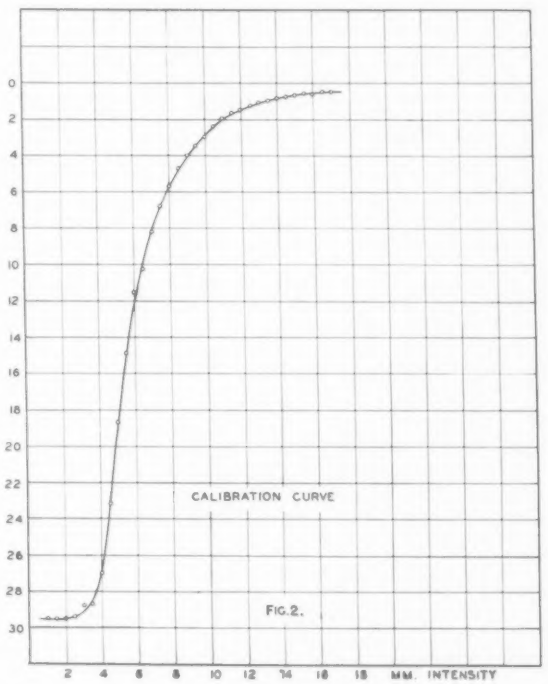

FIG. 2. Calibration curve obtained with uniformly increasing illumination film.

kind as that used for making the spectra) placed between the intensifying screens in the small cassette used in the spectrograph. This cassette was slowly removed at uniform speed from underneath a lead plate while being exposed at a low intensity to well filtered roentgen rays generated by about the same voltage as that used for making the spectra. This radiation contained, therefore, approximately the same wave lengths and the same intensities of roentgen rays as those which formed the spectrum. This film was photometered in the same fashion as the spectra and the bottom line (abscissa) along this film represents the radiation intensities. By transposing the photographic intensities measured with this curve, an intensity curve is obtained which differs quite considerably from the original photographic curve.

Figure 3 shows the direct photometric result from the spectral film and Figure 4 shows this curve transposed into an intensity curve which, therefore, is a considerably better representation of the absolute roentgen-ray spectrum.

From the interesting work of Glocker, we learn that intensities at equal wave lengths can be used as a measure for comparison but that intensities measured at different wave lengths are not comparable. This would bring us somewhat closer to

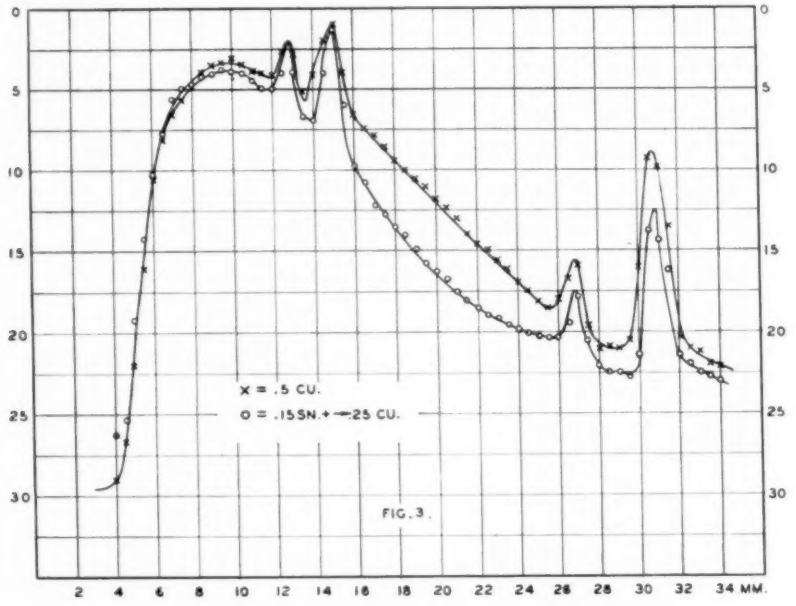

FIG. 3. Photographic blackening of a spectrum film.

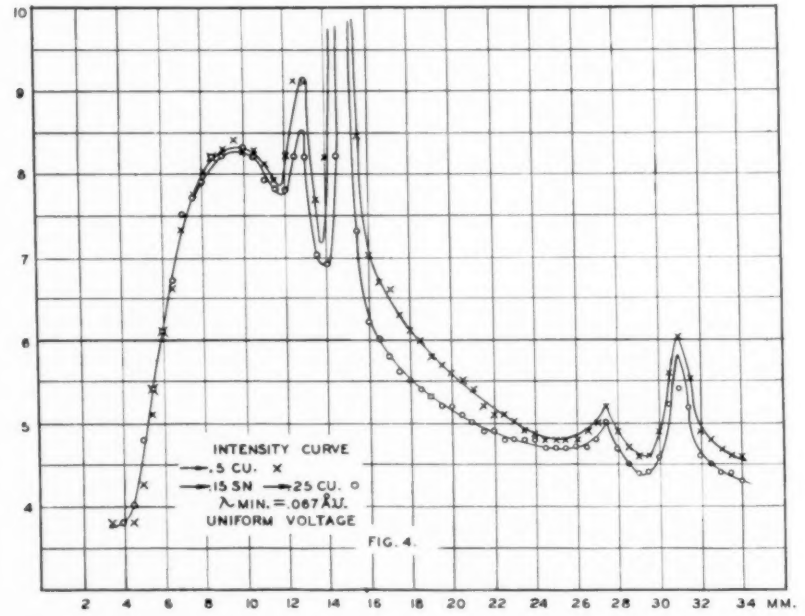

FIG. 4. Intensities corresponding to photographic blackening of Figure 3, obtained through conversion of blackenings into intensities with the aid of the calibration curve (Fig. 2).

knowing the true outline of roentgen-ray spectra (Kulenkampff).[4]

This method of photometering photographic densities might also prove of distinct advantage in determining the quality of photographic films such as in regard to differences in density or clarity, the scale of gradation of tints or the influence of intensifying screens upon the scale of gradation, which would serve as a measure of the quality of the intensifying screen alone or in combination with the given photographic material.

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EDITORIALS

HEALTH INSURANCE

PAYMENT for medical care may be made in accordance with the age-old custom, directly by the patient to the physician, or it may be made indirectly through some type of health insurance plan.

Plans for insurance vary widely in their details as to the groups insured, the scope of the medical service, and the methods of payment for services to the practitioners and hospitals.

The groups may be composed of the employees in a single industrial establishment or of several establishments located in the same community; of members of a union or fraternal or religious organization; of students and faculty of college or university; or they may be formed with the sole purpose of securing medical and hospital care through insurance. One of the limitations of health insurance is that it has not been found financially feasible to sell such insurance to individuals outside of groups.

The methods of periodic payment may be through weekly, monthly, quarterly or yearly contributions into a common treasury or to an insurance company, benefit association, hospital association or group of physicians.

The practitioners may be paid through an annual capitation fee based upon the number of insured persons, through services rendered according to a fee schedule, or by fixed salary.

The scope of medical service may be limited to industrial injuries, to such diseases as can be cared for by a general practitioner, or it may include all types of medical and hospital care.

Health insurance should not be confused with "group hospitalization" insurance. The latter, which is now being developed in a number of cities, does not include any type of medical care and by proper safeguards can be kept free from all of the evils that have usually attended health insurance.

Health insurance may be of the voluntary or compulsory type. Compulsory insurance is established by law; the state compels its adoption and controls its operation. Nearly all European countries have this type of insurance at present after long-continued trial of voluntary methods. Workmen's compensation is the only compulsory insurance in effect in the United States.

Voluntary insurance in the United States may be divided into the following types:

1. Accident and Health Insurance. The standard accident and health policies written by many American insurance companies simply pay a cash benefit to cover loss of income during sickness. The same kind of protection is afforded by the benefit funds of certain trade unions and fraternal societies.

2. Proprietary Medical Insurance Associations. A great variety of such associations have been formed in many different localities. Briefly and in a general way, these associations are commercial ventures organized by laymen or doctors with a flair for business organization to sell the services of physicians to groups of laymen under some type of fixed periodic payment plan.

3. Group Payment for Medical Care without Intermediate Agency. Under this method the physician or group of physicians deals directly with groups of laymen and furnishes medical care for fixed periodic payments.

The uneven distribution of sickness and its unpredictable incidence are the principal facts upon which arguments are based

for health insurance. The sickness bill of the United States, if evenly distributed, would amount to about $30 per person annually. Based upon these figures the logic of spreading the cost over the entire population, or at least over large groups, seems inescapable.

On the other hand, health insurance, either voluntary or compulsory, has never run a smooth course. Experience has demonstrated many disadvantages and evils in its actual operation. The advocates of health insurance believe that the evils are not inherent in the method and think that they can be eliminated in this country as new plans are developed. There are many others, among them the majority of physicians, who have serious misgivings that any system of health insurance can be operated without giving rise to the evils apparent in all insurance plans in the past.

Whatever decision is reached finally for the place of health insurance in the United States, there are certain facts which have been established by European experience which all should know. There is no advantage in entering upon the path of insurance medicine in this country harboring hopes which experience has proved to be without foundation.

Among the facts which may be considered settled are the following:

1. Contrary to original beliefs, health insurance has not shown any appreciable influence in the prevention of disease or in lowering the mortality rate.

2. It is well established that health insurance invariably increases the morbidity rate in the insured population. The number of days sickness per capita has more than doubled in both Germany and England in the comparatively few years of operation of compulsory insurance in those countries. However this may be explained by supposing that more cases are reported or that treatment is more inclusive of those who need it, there is still a great increase which is due to so-called compensation neuroses and intentional prolonging of sickness.

3. The history of health insurance in Europe demonstrates beyond doubt that voluntary insurance is always superseded by a compulsory system. The success of any system is in direct proportion to the degree of compulsion.

4. It is not only true that the compulsory system always follows the voluntary but compulsion always results in a high degree of state control with gradually increasing state participation in supplying the funds, and finally in state operation. These events have followed each other so regularly that they may be considered the natural and probably inevitable sequence in health insurance.

5. Any insurance system tends gradually to widen its scope. Systems usually begin with industrial laborers and gradually reach out to include workers in commerce, agriculture and domestic service. The upper income level is gradually raised and the benefits are gradually increased until they include almost complete medical and hospital care. The system always begins with the wage earner but after a time includes his dependents. When the state begins to use tax funds to subsidize health insurance there is a very natural desire on the part of classes excluded because of income limitation or for other reason, to participate in the apparent benefits which are being paid for in part by the general tax-paying public.

6. There is no proof that health insurance effects a decrease in the costs of medical care. On the contrary, there is good reason to believe that such cost is actually and materially increased. This is due to the cost of administration of the insurance system and to the fact stated above that the sickness rate increases under insurance.

7. Much of the difficulty of administration and a major cause of friction in health insurance systems is due to inclusion of unemployment cash benefits along with medical benefits. Their complete separation is difficult as is shown by the experience of England. There the two kinds of benefits are separate in their administra-

tion but it is still necessary for physicians to certify to disability for cash benefits. The clashing interests of the insurance societies and the insured are sources of constant irritation and conflict.

8. It is generally agreed by students of health insurance that "the evils of insurance decrease in proportion to the degree that responsibilities, with accompanying powers and duties, are intrusted to the medical professions."*

9. There is no proof that the quality of medical care provided under insurance is better than that under the old system. The evidence on this point is so conflicting and interpretation of the facts so difficult that no accurate judgment is possible.

The principles stated above have been so thoroughly established that they are hardly open to question. They should be understood and accepted by all who advocate the entrance of the United States upon the path of health insurance.

At this point should be considered the evils alleged against the operation of health insurance. It is probable that many of them can be eliminated but it cannot be denied that most of them are prevalent in the voluntary plans now operating in the United States.

The most important of these evils are as follows:

1. Control of medical practice by insurance companies.

2. Development of proprietary groups under lay control to sell medical service.

3. Elimination of free choice of physician.

4. Destructive competition among organized professional groups, giving rise to underbidding for contracts, solicitation of patients and many other objectionable commercial practices.

5. Since the easiest method to furnish medical care under insurance is through contract with a group of physicians or proprietary medical association, the tendency is to substitute the group for the individual physician. The individual relation between patient and physician is difficult or impossible to maintain under such methods of practice.

6. A high degree of political control is inevitable when governmental compulsion becomes operative. It is well known that political considerations were the principal impelling motives for the original adoption of compulsory health insurance in Germany, and that the insurance societies have been powerful political instruments. Added to political control of medical practice is the expense of the bureaucracy which must be built up to administer the insurance system.

Notwithstanding the above limitations and objections to health insurance, the method is advocated strongly by sociologists and others as the most desirable method of furnishing medical care to a large proportion of the American people. It is claimed that the advantages of spreading the costs of medical care outweigh the objections.

The problem must be examined further, however, before it is admitted that health insurance is the only solution, or even a proper solution, to the complicated problem of furnishing medical care to the American people.

Before we commit ourselves to voluntary insurance in this country, let us face the facts candidly and let us admit that we are willing to enter upon the course plainly marked out by European experience, the course that leads from voluntary to compulsory insurance and to a high degree of state control. Let us enter upon this course with the full knowledge that it is not a method by which we can hope to reduce the costs of medical care or improve methods of disease prevention or reduce the mortality rate. Let us further remember that health insurance is still in an experimental stage. Even in Germany where it first came into use it has been in existence for a comparatively short time. Everywhere, it has undergone constant change, experiment after experiment, to render it more workable and less harmful. Its operation in different countries today is so

* The Way of Health Insurance. Simons and Sinai. p. 20.

varied that it scarcely seems the same system.

Finally, let us remember that health insurance at its best can furnish only a small part of the solution of the complex problem of caring for the people's health.

After all the study and investigation and the voluminous writings on the subject of medical care, beginning with the volume of H. H. Moore* and including the five-year study of the Committee on the Costs of Medical Care, the only solution that has been proposed by sociologists, economists, statisticians, business men, and executive secretaries of foundations is *health insurance*. Undoubtedly they have over-emphasized its importance. It is no panacea and must be judged by those willing to face the facts of experience as an expedient of limited value which is still in an experimental stage.

It is not to be wondered at that the medical profession still views it with doubt and distrust and casts about for other solutions that have less the appearance of desperate expedients and a sounder foundation in past experience.

The Minority Report of the Committee on the Costs of Medical Care expresses the views of the great majority of American physicians on this subject. That this is true cannot be doubted by anyone who has followed the official pronouncements of representative county, state and national organizations. It was only on the combined question of group practice and health insurance that the Minority differed essentially from the Majority of the Committee. The medical profession, whose convictions are embodied in the Minority report, favors all of the forward looking movements recommended by the majority and has consistently supported such movements in practice.

A problem so complicated as medical care and which is as broad as society itself cannot be fitted into any single ready-made plan. The empirical method is the best method to adopt in dealing with most social problems since the very application of a new method to the conditions that prevail in society at any given time may change many of the elements of the problem.

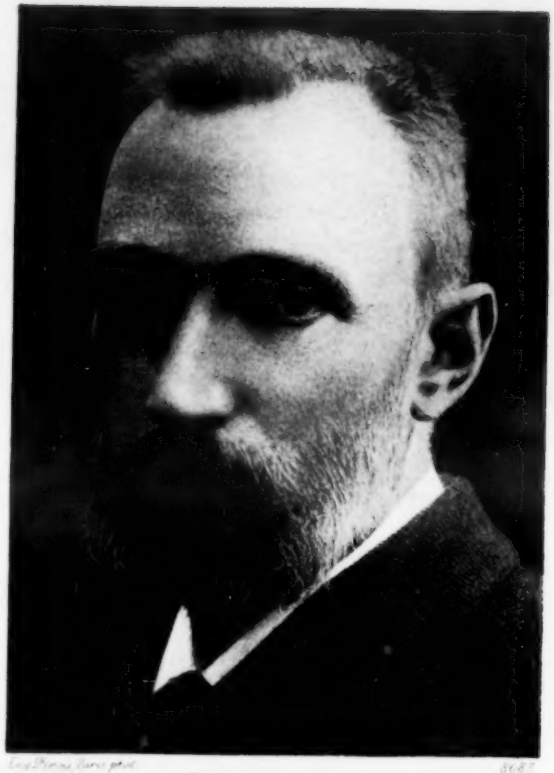
Whatever plans are finally developed it should be recognized that the medical profession is best fitted by training and experience to bear the responsibility for leadership in everything that pertains to medical care. To object that the profession has not the proper social training or outlook for such responsibility is simply begging the question. If this be true then the profession must receive the necessary training. The results for society will be much better if the leaders in sociology, public health and medical philanthropy will assist the profession to make necessary adjustments in the present system, rather than threatening, as has often been done of late, to force the medical profession into an entirely new system which it believes ill-adapted to the ends desired. That society has the power to coerce the profession to adopt whatever system it finally decides upon is undoubted, but that society or medical progress will thus be best served is open to grave doubt.

ARTHUR C. CHRISTIE

* Moore, Harry H. American Medicine and the People's Health. Appleton.

UNIV OF MICH.

Marie Curie



Pierre Curie

Photographische Gesellschaft Berlin

MARIE SKLODOWSKA CURIE

MADAME CURIE has ceased her labors. The test tube, the crucible, the pen, have fallen from her weary hands and she has entered on a well-earned rest. The world was startled when it learned that so great a life had ended. It paused a moment in shocked surprise—then, all the great and humble seemed to join in mourning and praise of her. However, words are weak and praise seems futile; her life and work speak for themselves in glowing terms that all can understand.

Marie Sklodowska was born in Warsaw, Poland, November 7, 1867, the youngest of five children. Hers was an unusual heritage, for her father, Ladislas Sklodowska was a physicist and professor in the Warsaw Lycée and her mother, Bronsitawa Boguska was principal of a school for girls. As a child she played with test tubes and crucibles and soon showed such a keen mind and developed such studious habits that at an early age she became her father's chief assistant. At seventeen, she assumed her first teaching position as a governess.

Her independent spirit and her strong love of her native land led her into trouble with the Russians then ruling Poland. She was one of a group of young people encouraging Polish national spirit and making a determined effort to preserve the Polish language. It was necessary for her to leave Poland so she went to Crakow, then under Austrian rule, thence to Paris where at the age of twenty-four she entered the University of Paris to work toward a doctorate. For five years she lived in a garret, carrying her own coal up five flights of stairs and allowing herself only ten cents a day for food. She was indeed happy to be given a job washing bottles in a laboratory and cleaning the furnace. Despite her humble occupations her spirit and her work attracted the attention of the great physicist Lippmann, and the mathematician Poincairé who, with her father's assent and influence, had her assigned to the personal tutelage of the young physicist, Pierre Curie, the son of a Paris physician. In 1895 after years of constant association in scientific study, Marie and Pierre were married. They continued their studies as before. M. Curie was an instructor in a Paris Municipal School for Chemistry and Physics on Rue Lohmand, and Marie obtained a position as a teacher in a girls' school in Sevres. Their study and research work were carried on at night in the poorly equipped laboratory of the municipal school.

Roentgen had at this time just announced his discovery of the x-ray and the whole scientific world was started on a new set of experiments. Henri Becquerel, working with uranium salts, found by accident that some of his photographic plates were fogged, though protected from ordinary light. He next discovered the ionizing effect of uranium on air and found that the effect was proportional to the strength of the rays. He then called in his friends, the Curies, as expert analysts to aid him in determining the nature and source of the radiant energy.

After verifying the experiments of Becquerel, Marie and Pierre started a set of experiments of their own, using an electrometer designed by Pierre to which Marie added a suitable ionization chamber. With her characteristic patience and thoroughness she put almost every known element and compound to the electroscopic test and found that only compounds of thorium and uranium manifested this ionizing power, to which she gave the name "radioactivité." In the course of her experiments she found that pitchblende, from which uranium was obtained, was a more powerful ionizing agent than could be accounted for by its uranium content and immediately concluded that pitchblende must contain some other radiant substance. She set herself to the task of finding that source of energy.

A huge task it was, for even the richest

pitchblende contained only traces of radiant material. Through the influence of the Vienna Academy of Sciences a ton of pitchblende was placed at her disposal, to handle which it was necessary to rent an old abandoned warehouse for use as a laboratory. It had a patched glass roof which leaked when it rained, an old asphalt floor, and was poorly ventilated, being hot in summer and scantily heated in winter by a cast iron stove. Its furnishings consisted of three old deal tables, and on these Madame Curie prepared and mixed her chemicals, using crude apparatus that would be scorned by modern chemists. Enormous physical labor was required, for each part of pitchblende analyzed required five parts of added chemicals and about fifty parts of water. We wonder at the scientific zeal of this frail woman who could teach by day and spend many evening hours and much of the night in such exhausting mental and manual labor, at the same time maintaining a home. The work of those years with its brilliant results is the more remarkable due to an intervening pregnancy and the birth of her first daughter in 1897. Small wonder Irene Curie Joliot has already become a scientist of note, following in the footsteps of her illustrious mother!

After many months of laborious and tedious crushing, dissolving, precipitation, and distillation, with fractional crystallization and painstaking ionization tests of each product at every step of the process, a thimbleful of white salt was obtained which was very strongly radioactive. From this Madame Curie isolated in July, 1898, a substance which she named "polonium," in honor of her beloved native land. On December 26, 1898, she announced the discovery of an element emitting two million times as much radiant energy as uranium and to which she gave the name "radium."

Madame Curie did not rest idly on her laurels and enjoy the fruits of her scientific discoveries. Her life work had only begun. She and her husband set about experimenting with the new-found substances, determining their properties and actions and evolving new and better methods of isolating them from the mother ores. Her experiments furnished the basis for her final thesis for her doctorate submitted in 1903. She and Pierre investigated and published papers concerning induced radioactivity, radium emanation, heat emission by radium and numerous other purely scientific studies, and began to investigate the physiological effect of radium rays. M. Curie intentionally produced a strong reaction on his own arm and they began a long series of experiments with animals to determine biological effects, which really laid the foundation for modern radium therapy.

In 1904 a second daughter Eve, now a dramatist and pianist of considerable talent, was born, and with slightly better financial circumstances it seemed that Madame Curie might be able to devote more time to her home and family. However, when the child was but two years of age Pierre Curie met a tragic death in a traffic accident and his wife was deprived of her dear companion and coworker and was left to carry on the struggle alone. She accepted his chair of physics at the Sorbonne where she continued his lectures and also carried on her experimental work at the Institut Curie—her private laboratory, established in 1912.

When the World War broke out, Marie Curie offered her services to France. She closed her Institut and with her daughter Irene and several student followers, put her knowledge of radiography to excellent use in hospitals near the battle front. She suggested the use of portable roentgenographic units in ambulances and was the means of saving many lives by early localization of foreign bodies.

Though shunning publicity, for the sake of science and humanity she wrote many papers and delivered many lectures. Among her writings are "Recherches sur les propriétés magnétiques des aciers trempes," "Recherches sur les substances radio-

actives," "L'isotropie et les elémentes isotropes" and "Pierre Curie." Her most important work, however, is the scientific classic "Traité de radioactivité" published in 1910. Madame Curie was a product of the past generation and her scientific theory was of the old school. Her discoveries and evolved theories, however, formed the starting point for the brilliant new school of scientific theorists. Her belief that radioactivity was a property of all matter, that all elements originated from radioactive elements instead of being distinct and indestructible, provided a basis for the modern ideas regarding the structure of the atom with its protons and electrons.

To few persons is it given to achieve greatness; to fewer still to have that greatness recognized and acclaimed by the entire world during their lifetime. To Marie Sklodowska Curie came not only the usual reward of work well done, to her came the rare privilege of seeing her labors bear great fruit in advancing the border of scientific knowledge as well as in being put to practical use in the world of industry and in the alleviation of human ills. And the world was not slow or niggardly in honoring the Curies. The street in Paris on which they lived was renamed Rue Pierre Curie, and many institutions bear their name. The literature of radium physics incorporates their name as a unit of measurement, the commonly used "millicurie," and radium therapy is properly called "curie therapy."

In 1901 Pierre Curie was awarded the Lacaze prize of 10,000 francs. In 1903 they received the Davy medal of the Royal Society of London. In 1904 they shared with Becquerel the Nobel Prize in Physics. Pierre was made a full Professor at the Sorbonne and in 1905 was elected to the French Academy of Sciences. In 1911 Madame Curie received the Nobel Prize in Chemistry, the only person ever to have been so honored a second time, and was also elected to the French Academy. In 1922 she was elected to the Academy of Medicine of Paris.

She returned to Warsaw for the first time in 1913, receiving signal honors. She visited the United States first in 1921 and again in 1929, each time being overwhelmed with ovations and laudatory introductions at receptions in her honor. Honorary degrees were bestowed upon her by Columbia, Yale, Northwestern and St. Lawrence Universities, the Universities of Pennsylvania and Pittsburgh, Woman's Medical College and Wellesley and Smith Colleges. In 1926 she delivered a series of lectures in South America, receiving the usual acclaim as a leader of scientific endeavor.

The strain of her many travels, the demands of the public, her teaching, and the private experiments she refused to give up, at last began to take their toll of physical strength. She was so tired following her first visit to the United States that she became seriously ill. In April, 1932, she was gravely injured by a fall in her laboratory and a surgical operation was necessary. In accordance with her wishes her last illness was unknown except to the family and a few intimate friends. After five weeks in a Paris hospital, she was removed for a few days to a Sanitarium in Sallanches on the upper Savoy, where the world's foremost woman scientist died July 4th, 1934. Her personal physicians attributed her death to a wasting anemia, produced, or at least aggravated, by the long contact with powerful radiation. That her frail frame had so long endured was no doubt due to the dominance of her forceful mind.

Neither of the Curies deigned to profit from their discoveries. No patents were obtained, no secrets regarding methods or processes kept, and all knowledge or theory was freely given to their fellow scientists. Prizes and awards of money were turned to scientific experiments or given to hospitals for furtherance of cancer work. Mme. Curie never owned a particle of the radium she produced until 1921 when she accepted a gift of $100,000 presented by President Harding from the women of America for the purchase of a gram of radium for ex-

perimental work. This gram was obtained from 500 tons of carnotite ore. However, she rented that radium for $3500 a year and gave the money to a cancer hospital in Warsaw. The purchase of a second gram was made possible by the donation of $50,000 on her second visit to America, President Hoover this time making the presentation. On the occasion of the twenty-fifth anniversary of the discovery of radium the French government unanimously voted her an annual pension of 40,000 francs. In honor of Marie, her daughter Irene was given an endowment of over $56,000 by American women to enable her to pursue her scientific research.

Despite financial rewards, and countless more had been hers for the asking, Marie Curie continued to live simply and frugally, giving freely of her surplus to science and to charity. By her own direction even after death there was no extravagant display or pomp or ceremony, and the people she so loved respected her last wish. But no power could lessen the intense feeling of gratitude and reverence the world holds for the great woman who has just passed from us. No nobler example of unselfish sacrifice for science and humanity has ever been presented. How oft her frail body must have ached and her tired mind yearned for quiet rest with her family! How oft must she, as human as the rest of us, have been tempted to enjoy in luxury of later years the fruits of earlier toil! Her devotion to her science was extreme, it vied only with her devotion to her family and her husband. Pierre was ever her inspiration and she unselfishly deferred to him honors intended for her and gave him credit as a co-discoverer of radium along with many other achievements. His precept—"Make life a dream, make dreaming a reality"—was carried out by both of them on the highest possible plane.

We of the radiological world are peculiarly moved by the death of Madame Curie. In life she was one of us, a leader in our cause of conquering the enemies of life through advancement of scientific knowledge. Of all her achievements it is said she was most proud of having found a new agent for alleviating human ills. We are grateful to her for the opportunity to use this agent in our work as radiologists. We sorrow with the scientific world that so brilliant a mind, with its rich store of knowledge and wisdom should be halted in its activity. We rejoice with humanity that Madame Curie was permitted so many years of invaluable service to mankind. We are fortunate to have been contemporaries of such a pioneer—future generations will no doubt envy us the personal contact that has been the privilege of so many of us. Poland may justly feel proud as the native land where she received her early training; France may, with pardonable pride, take credit for the great work carried on within her borders; the world in general rejoices that so great a scientist lived to such good purpose. However, only those who combine pure science with personal service to humanity can fully appreciate the life of sacrifice and service which was hers.

E. WALTER HALL

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa.
Annual Meeting: Hotel William Penn, Pittsburgh, Pa., Sept. 25–28, 1934.

American College of Radiology
Secretary, Dr. Albert Soiland, 1407 S. Hope St., Los Angeles, Calif.
Annual meeting: Atlantic City, N.J., 1935.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio.
Annual meeting: Atlantic City, N.J., 1935.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y.
Annual meeting: Memphis, Tenn., Dec. 3–7, 1934.

Radiological Section, Baltimore Medical Society
Secretary, Dr. W. B. Firor, 1100 N. Charles St., Baltimore
Meets third Tuesday each month, September to May.

Radiological Section, Los Angeles County Medical Society
Secretary, E. N. Liljedahl, Los Angeles, Calif.
Meets on the third Wednesday of each month at the California Hospital.

Radiological Section, Southern Medical Association
Secretary, Dr. F. B. Bogart, Medical Arts Bldg., Chattanooga, Tenn.
Annual meeting: San Antonio, Texas, November, 1934.

Brooklyn Roentgen Ray Society
Secretary, Dr. A. L. Voltz, 115 Myrtle Ave., Richmond Hill, N.Y.
Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N.Y.
Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt.
Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. H. G. Reineke, General Hospital, Cincinnati, Ohio.
Meets third Monday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. Otto Glasser, Cleveland Clinic.
Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital.
Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

Florida Radiological Society
Secretary, Dr. W. McL. Shaw, 418 St. James Bldg., Jacksonville, Fla.
Meetings held twice a year, May and November.

Illinois Radiological Society
Secretary, Dr. H. W. Grote, 219 N. Main St., Bloomington, Ill.
Regular meetings held quarterly.

Indiana Roentgen Society
Secretary, Dr. J. N. Collins, Indianapolis, Ind.
Annual meeting each February 22 in Indianapolis.

Michigan Association of Roentgenologists
Secretary, Dr. S. W. Donaldson, St. Joseph's Mercy Hospital, Ann Arbor, Mich. Three meetings a year, Fall, Winter, and Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis.
Meets monthly. Place of meeting designed by the president.

Minnesota Radiological Society
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

New England Roentgen Ray Society
Secretary, Dr. Thomas R. Healy, 370 Marlboro St., Boston Mass.
Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. P. S. Avery, New Brunswick, N. J.
Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

New York Roentgen Society
Secretary, Dr. E. F. Merrill, 30 W. 59th St., New York.
Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N.C.
Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. F. C. Rulison, Medical Arts Bldg., Syracuse, N.Y.
Three meetings a year—January, May, and November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif.
Meets annually, during meeting of California Medical Association

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, Williamsport, Pa.
Annual two-day meeting held during May. 1935 meeting, to be announced.

Philadelphia Roentgen Ray Society
Secretary, Dr. Thomas Loughery, Germantown Hospital.
Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Rochester Roentgen Ray Society, Rochester, N.Y.
Secretary, Dr. W. W. Fray, Strong Memorial Hospital
Meets monthly on second Thursday from October to May, inclusive, at 7:45 at the Rochester Medical Association Building.

St. Louis Roentgen Club
Secretary, Dr. W. K. Mueller, University Club Bldg.
Meets first week of each month. Time and place of meetings designated by president.

South Carolina X-Ray Society
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston.
Meets at time and place of South Carolina State Medical Association.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

VIRGINIA ROENTGEN RAY CLUB
Secretary, Dr. Wright Clarkson, 205 S. Sycamore St., Petersburg, Va.
Next meeting, to be announced.

CUBA

SOCIEDAD CUBANA DE RADIOLOGIA Y FISIOTERAPIA
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

ELECTRO-THERAPEUTIC SECTION OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8:30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

SECTION ON RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

CONTINENTAL EUROPE

BELGIAN SOCIETY OF ROENTGENOLOGY
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium)
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

SOCIÉTÉ DE RADIOLOGIE MÉDICALE DE FRANCE
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

SOCIÉTÉ FRANCAISE D'ELECTROTHÉRAPIE ET DE RADIOLOGIE MÉDICALE.
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

ASSOCIATION OF GERMAN ROENTGENOLOGISTS AND RADIOLOGISTS IN CZECHO-SLOVAKIA
Secretary, Dr. Walter Altschul, German University, Prague, II. 52.

DEUTSCHE RÖNTGEN-GESELLSCHAFT (GESELLSCHAFT FÜR RÖNTGENKUNDE UND STRAHLENFORSCHUNG)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

SÜD- UND WESTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

NORD- UND OSTDEUTSCHE ROENTGENGESELLSCHAFT
Meets annually in different cities.

DUTCH SOCIETY OF ELECTROLOGY AND ROENTGENOLOGY
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

SOCIETA ITALIANA RADIOLOGIA MEDICA
Secretary, Professor M. Ponzio, University of Turin, Turin.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE
Secretary, Dr. Nicolae Busila, 44 Elizabeta Blvd., Bucarest.
Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8'clock, the place of meeting being selected by the Society.

POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

WARSAW SECTION, POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

SOCIETY OF MEDICAL RADIOLOGY OF SWEDEN
Meets in Stockholm.

SOCIETY OF MEDICAL RADIOLOGY IN NORWAY
Meets in Oslo.

SOCIETY OF MEDICAL RADIOLOGY IN DENMARK
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8'clock in the State Institute of Roentgenology.

SOCIETY OF MEDICAL RADIOLOGY IN FINLAND
Meets in Helsingfors.

VIENNA SOCIETY OF ROENTGENOLOGY
Secretary, Professor Holzknecht, Vienna, IX, General Hospital.
Meets first Tuesday each month, October to July.

ORIENT

JAPAN X-RAY ASSOCIATION
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

KINKI ROENTGEN-ABEND SOCIETY
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto, Japan. Meets bi-monthly on third Sunday.

SOME IMPORTANT PHASES OF MEDICAL ECONOMICS

RECENT PRONOUNCEMENTS ON SICKNESS INSURANCE BY THE AMERICAN MEDICAL ASSOCIATION AND THE AMERICAN COLLEGE OF SURGEONS

The following extracts from a "Report of Medical Service Board of the American College of Surgeons to the Board of Regents on June 10, 1934," and from a report of a Special Committee to the House of Delegates of the American Medical Association are published for the information of our readers.

1. *Extract from Report of Medical Service Board of the American College of Surgeons.*

The American College of Surgeons recognizes that the periodic pre-payment plan providing for the costs of medical care of illness and injury of individuals and of families of moderate means offers a reasonable expectation of providing them with more effective methods of securing adequate medical service.

A number of different plans for the organization of such services have been proposed, although few have been in operation long enough to permit definite conclusions in regard to their success. It is to be desired that these experiments be continued. Conditions differ to such a degree in different parts of the country that a specific plan which is practicable in one place may require modification of details in other communities. The varying restrictions imposed by present insurance laws in different states further complicate the problem.

Periodic pre-payment plans providing for the costs of medical service may be divided into two classes:

A. Payment for medical service.

B. Payment for hospitalization.

It is suggested that plans for the payment of hospitalization alone (Class B) without provision for payment for medical service, may be considered the first project to be undertaken in the average community.

The American College of Surgeons believes that certain general principles can and should be established, the observance of which will tend to obviate known difficulties and dangers which may threaten the success of these special forms of medical service. These principles are as follows:

a. Periodic pre-payment plans for medical service should be free from the intervention of commercial intermediary organizations operating for profit. After deduction of the clerical costs of operation of the fund and such accumulation of reserve as may be advisable in the interest of the contributors or may be legally imposed, the full amount paid by the contributors should be available for medical and hospital services.

b. In the interest of the patient, the organization of plans for the periodic payment of medical and hospital costs must be under the control of the medical profession. The medical profession must act in concert with the hospitals and such other allied services as may be involved in the individual project, together with a group of citizens representative of the whole comumnity and of industry who are interested in the successful operation of the plan.

c. The principle of free choice of the physician and hospital by the patient must be assured to the end that the responsibility of the individual physician to the individual patient shall always be maintained. When hospitalization is required, this choice must of necessity be limited to the physicians and surgeons who hold appointments on the staffs of the hospitals participating in the plan or to those physicians and surgeons who are acceptable to the hospital. It is further recommended that only approved hospitals be admitted to participation in such a plan.

d. The compensation of the physician and of the hospital should be estimated with due regard to the resources available in the periodic payment fund and should be based upon the specific services rendered.

e. The organization and operation of any plan of this type must be free from any features not in accordance with the code of ethics of the medical profession which code has been established for the protection of the patient.

f. The medical organizations participating in such a plan must assume the responsibility for the quality of service rendered.

2. *Extract from Report of Special Committee to the House of Delegates of the American Medical Association.**

The Chairman of the Board of Trustees presented the following statement at an earlier session of the House:

Since 1912, when the British government, through the action initiated by Lloyd George, established a system of compulsory health insurance, this problem has been prominently before the House of Delegates and other official bodies of the American Medical Association. As early as 1916, the House of Delegates requested the Board of Trustees to undertake an investigation of social insurance in all its forms and to make suitable report to the House. The subject has been raised from time to time since that date. On every occasion on which the House of Delegates has officially considered the questions of compulsory health insurance and social insurance, as well as the entrance of the state into medical practice, it has reaffirmed the independence of medicine as a profession and it has always condemned any system whereby the state would in any way enter into the practice of medicine. In 1920, following the report of the committee appointed to study compulsory health insurance, the House of Delegates adopted a resolution strongly condemning all forms of compulsory health insurance.[1] It is a well known fact that voluntary insurance has always been the forerunner of compulsory insurance, and even the most ardent advocates of voluntary insurance admit that fact. The action of that House of Delegates has not been rescinded by any subsequent action taken by the House of Delegates.

As far as state medicine is concerned, the House of Delegates in 1921 adopted a resolution approving and endorsing all activities and policies of the states directed to the prevention of disease, but opposing the state treatment of disease except for the delinquent and the defective.[2] Again in 1922 the Association declared its opposition to all forms of state medicine because of the ultimate harm that would come thereby to the public weal through such form of medical practice.

The Judicial Council of the Association has repeatedly brought reports to this House of Delegates sustaining the same point of view; these reports of the Council have been accepted and approved by the House of Delegates.

Finally, last year the House of Delegates unanimously approved in principle the Minority Report of the Committee on the Costs of Medical Care and urged that the Board of Trustees of the American Medical Association in cooperation with its constituent bodies conduct an intensive campaign to disseminate this point of view among the medical profession and the public, with a view to the maintenance of high ethical standards and the preservation of professional ideals.

Your Board of Trustees, your executives and all the publications of this Association have done their utmost thus far to carry out the policies which you have established. Today we are confronted with an extraordinary situation of the utmost importance to the health and welfare of the American people and to the American medical profession. It is no secret that a considerable number of foreign nations have already established state systems of medical care and that an intensive campaign has been carried on in this country for many years, led by philanthropists, social workers, economists and various foundations, to cause the American medical profession and the American people to accept a similar type of medical practice. In accordance with the mandate of this House of Delegates, all the facilities of the American Medical Association have been used to oppose this trend and the propaganda in support of it, which has been widely circulated and for which vast sums of money have been, and are being, expended by various interested parties. It is also now well known that the President of the United States, in a recent message, has come forth for the principle of social insurance, with special reference to old age pensions and unemployment insurance.

In 1930 the House of Delegates recommended to the Board of Trustees the establishment of a Bureau of Medical Economics in the headquarters office for the study of all these problems as they affect the medical profession. From time to time this Bureau has issued bulletins of the greatest importance, not only for the factual data which they present but also for the interpretation of medical economic trends. In accordance with a special request by the Board of Trustees, your Bureau of Medical Economics has prepared an extended statement of the conditions in relationship to state medicine and compulsory insurance, as they exist in

* *J. Am. M. Ass.* June 30, 1934, *102*, 2199.

[1] Index and Digest, Official Actions of American Medical Association, p. 52.

[2] Index and Digest, Official Actions of American Medical Association, p. 175.

other nations. This statement was made available to all Fellows of the American Medical Association by publication in the Bulletin of the Association for April 1934. In connection with the publication of these data and this critical analysis, the Bureau of Medical Economics has also drawn up a statement entitled Sickness Insurance Problems in the United States, which purports to be an interpretation of the data already referred to and which includes a presentation of twelve basic principles, which should be given most careful study in relationship to any recommendations that this House may care to make on this problem for the future. This statement will now be distributed to the House of Delegates.

There are manifestations of unrest in relationship to the economic situation among some of the component and constituent bodies of this association. On several occasions, communications have been made to the Board of Trustees and to the headquarters office, urging a change in the activities of the organization which would in effect demand a departure from the policies set down by this House of Delegates during the past eighteen years. The problem is before you. The opportunity is offered here this afternoon for an extensive discussion of the situation as it confronts the medical profession today. The Board of Trustees hopes that you will give it earnest and careful consideration. Only the House of Delegates has the power to define the policies that are to guide this Association in the coming years.

Your committee believes that this statement of the Chairman of the Board of Trustees briefly reviewing the history of the action of the House of Delegates during the past eighteen years sufficiently illuminates the sincere and deep concern of the American Medical Association regarding all social programs affecting the delivery of medical service.

The delegates have in their hands a pamphlet entitled "Sickness Insurance Problems in the United States" as presented by the Board of Trustees.

Your committee does not recommend any plan but has abstracted from the pamphlet the following principles and suggests that they be followed by all constituent bodies of the American Medical Association as bases for the conduct of any social experiments that may be contemplated by them:

First: All features of medical service in any method of medical practice should be under the control of the medical profession. No other body or individual is legally or educationally equipped to exercise such control.

Second: No third party must be permitted to come between the patient and his physician in any medical relation. All responsibility for the character of medical service must be borne by the profession.

Third: Patients must have absolute freedom to choose a duly qualified doctor of medicine who will serve them from among all those qualified to practice and who are willing to give service.

Fourth: The method of giving the service must retain a permanent, confidential relation between the patient and a "family physician." This relation must be the fundamental and dominating feature of any system.

Fifth: All medical phases of all institutions involved in the medical service should be under professional control, it being understood that hospital service and medical service should be considered separately. These institutions are but expansions of the equipment of the physician. He is the only one whom the laws of all nations recognize as competent to use them in the delivery of service. The medical profession alone can determine the adequacy and character of such institutions. Their value depends on their operation according to medical standards.

Sixth: However the cost of medical service may be distributed, the immediate cost should be borne by the patient if able to pay at the time the service is rendered.

Seventh: Medical service must have no connection with any cash benefits.

Eighth: Any form of medical service should include within its scope all qualified physicians of the locality covered by its operation who wish to give service under the conditions established.

Ninth: Systems for the relief of low income classes should be limited strictly to those below the "comfort level" standard of incomes.

Tenth: There should be no restrictions on treatment or prescribing not formulated and enforced by the organized medical profession.

If it is determined in a community that some experiment to change or improve the method of administering medical service is desirable, observance of these principles will remove many of the "disturbing influences" from such an experiment. In all such experiments, attention must be

sharply focused on the quality of medical service.

Such restrictions will undoubtedly lower the enthusiasm of many of the present advocates of such schemes. They remove the interest of the politician, the commercial promoter and all those who consciously or unconsciously are seeking to achieve other objectives than better medical care for those unable to provide such care for themselves under present conditions. All these principles are directed toward protecting the character of the service to be given and all are directly designed to guard against abuses which experience shows are bound to arise when these principles are neglected. In most communities it will be found that comparatively few changes in the methods of administering medical care will be necessary. That type of medical practice which preserves the personal relationships between physician and patient, that maintains the practice of medicine as a profession, and that has withstood the test of centuries must be preserved for the best interests of both the public and the medical profession.

MADAME CURIE

A condolence meeting was held under the auspices of the Indian Radiological Association at the Calcutta Medical Club Hall, Calcutta, on July 13, 1934, to pay homage to the departed soul of Madame Curie. Captain M. Mukherjee presided. A brief reference was made to the life and work of the great scientist by Dr. Subodh Mitra, secretary of the Indian Radiological Association. The following resolution was passed:

The meeting places on record its deep sense of sorrow at the demise of Madame Curie, the most illustrious scientist and the greatest benefactress of suffering humanity.

FOURTH INTERNATIONAL CONGRESS OF RADIOLOGY

The Fourth International Congress of Radiology, held at Zurich and St. Moritz, Switzerland, has concluded a most successful session. A more detailed account of the Congress will be published in an early issue. The Fifth International Congress of Radiology will be held in the United States in 1937, at Chicago, Illinois, with Dr. A. C. Christie of Washington, D. C., as its President.

AMERICAN ROENTGEN RAY SOCIETY

Attention is again called to the Thirty-fifth Annual Meeting of the American Roentgen Ray Society to be held at the Hotel William Penn, Pittsburgh, Pa., on September 25 to 28, 1934. The preliminary program and other information concerning the meeting were published in the August issue of the Journal.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

De Venarum Ostiolis 1603 of Hieronymus Fabricus of Aquapendente (1533?–1619): Facsimile edition with introduction, translation and notes by K. J. Franklin, D.M., Tutor and Lecturer in Physiology, Oriel College and University Demonstrator of Pharmacology, Oxford. Cloth. Price, $3.00. Pp. 98, with 8 plates. Springfield, Illinois and Baltimore, Maryland: Charles C Thomas, 1933.

This book, which is a notable contribution to the history of medicine, is made possible by aid from the History of Science Society which has received an appropriation from the Carnegie Corporation of New York for the purpose of publishing or assisting to publish, important contributions to knowledge. The book is divided into 7 parts, as follows: Biographical Notice, The Early History of Work on the Venous Valves, The Theatre of the School of Anatomy at Padua, Biographical Note Concerning the First Edition of De Venarum Ostiolis, References, Translation, The Facsimilie and Reproductions of the Original Plates of the First Edition of De Vanarum Ostiolis, 1605, and the Sizes of the Original Plates.

While Fabricius was not the first to observe the valves in the veins, he was the first to give a detailed description of them and demonstrate them to his pupils. Fortunately for humanity, one of his students was William Harvey and the presence of valves in the veins led the latter to conclude that the blood circulates. The author relates in the preface a conversation between Robert Boyle and Harvey as follows:

"And I remember," he says, "that when I asked our famous *Harvey*, in the only Discourse I had with him, (which was but a while before he dyed) What were the things that induc'd him to think of a *Circulation of the Blood*? He answer'd me, that when he took notice that the Valves in the Veins of so many several Parts of the Body, were so Plac'd that they gave free passage to the Blood Towards the Heart, but oppos'd the passage of the Venal Blood the Contrary way: He was invited to imagine, that so Provident a Cause as Nature had not so Plac'd so many Valves without Design: and no Design seem'd more probable, than That, since the Blood could not well, because of the interposing Valves, be Sent by the Veins to the Limbs; it should be Sent through the Arteries, and Return through the Veins, whose Valves did not oppose its course that way."

The author should be congratulated upon the careful preparation of the material in the book and the attractive way in which it is presented. This publication will be welcomed by all students of medical history.

C. C. Sturgis

Clinical Miscellany. By Members of the Staff of The Mary Imogene Bassett Hospital, Cooperstown, New York. Cloth. Price, $3.00. Pp. 206, with 33 figures and 4 colored plates. Springfield, Illinois and Baltimore, Maryland: Charles C Thomas, 1934.

In this volume there are presented a series of 22 clinical studies on various interesting conditions which have been encountered by the members of the staff of this hospital. A wide variety of topics are covered in the fields of medicine, surgery and pediatrics and a number of the case reports are of unusual interest. Among the latter are 2 patients with chronic meningococcemia and an associated nephritis, 3 cases of botulism treated with antitoxin, spontaneous subarachnoid hemorrhage in a boy of eleven, and a patient with sulphemoglobinemia. The articles are well written and illustrated by a considerable number of tables, figures and 4 very excellent colored plates.

While there is nothing which is especially outstanding in this volume, nevertheless it can be read with profit by any physician.

C. C. Sturgis

The Universe of Light. By Sir William Bragg, O.M., K.B.E., D.Sc., F.R.S., Honorary Fellow of Trinity College, Cambridge; Fullerian Professor in the Royal Institution of Great Britain. Cloth. Price, $3.50. Pp. 283, with 110 illustrations in the text and 26 plates. New York: The Macmillan Company, 1933.

This enjoyable exposition by the author of "Concerning the Nature of Things" and "The

World of Sound" is based on the 1931 Christmas lectures of the Royal Institution, "adapted to a juvenile auditory"; but it has been expanded and deepened to a most delightful account of the earlier incidents and our present views regarding the nature of light.

The text contains a wealth of illustration, experimental and diagrammatic. The simple lucidity of the style will recommend itself to all.

"The Universe of Light" should be required reading for all students of roentgenology.

BARNETT COHEN

RADIOLOGIE DE LA VESICULE BILIARE. By Dr. Nemours-Auguste, Radiologist to the Hospice Paul Brousse. Preface by Prof. Gustave Roussy. Cloth, pp. 183. Paris: Masson et Cie, 1934.

To the growing literature of cholecystography is added this contribution from Nemours-Auguste, and by reason of its quality as well as the high standing of the author, the volume is entitled to respect. As might be anticipated from his introductory statement, the outstanding feature of the work is the author's extensive consideration of the anatomy, functional behavior, normal variants and anomalies of the gallbladder and ducts in relation to cholecystography. Throughout the book free use is made of diagrams as well as roentgenograms for illustration. The intravenous method of administration, which the author prefers, the oral procedure and the fractional technique are all described clearly but succinctly. Indeed an attractive quality of the book is its terseness and factuality. Facts are fortified by sufficient citations of authority, but references are not annoyingly profuse, and little attention is given to mere speculation and far-fetched hypotheses. English-speaking readers who often find French idioms difficult to understand can readily comprehend the clear language of this book.

B. R. KIRKLIN

ÜBER DIE WIRKUNGEN DER RÖNTGENSTRAHLEN AUF DIE LUNGEN. (The Effects of Roentgen Rays on the Lungs.) By Rolf Bull Engelstad. (*Acta radiol.*, Suppl. xix.) Paper. Price, Swed. cr., 9.00. Pp. 94, with 35 illustrations. 1934.

Engelstad reports the results of experiments he carried out on 101 rabbits with radiations varying from 65 kv. with no filter to 175 kv. and 7 mm. copper filter, the dose varying from the subepidermicidal to lethal doses for rabbits. These doses were administered in either one day or in twelve days at most. The typical changes are illustrated in reproductions of photomicrographs in the text and are correlated with the effects observed in man.

The book is important to those having a special interest in the biological effects of roentgen rays and to most radiologists, for it explains some of the puzzling reactions which occasionally follow irradiation of the chest.

E. T. LEDDY

RÖNTGENOLOGISCHE STUDIEN ÜBER DIE TRAUMATISCHEN UND HABITUELLEN SCHULTERGELENDVERRENKUNGEN NACH VORN UND NACH UNTEN. (Roentgenologic Studies of Traumatic and Habitual Dislocations of the Shoulder, Anterior and Inferior.) By Ivan Hermodsson. (*Acta radiol.*, Suppl. xx.) Paper. Price, Swed. cr., 9.00. Pp. 173, with 15 plates. Lund: Håkan Ohlssons Buchdruckerei, 1934.

In this monograph Hermodsson writes a thorough review of the important works on shoulder joint diseases. Then he analyzes a series of ninety-two cases of dislocation of the shoulder joint which he studied by special roentgenologic techniques. This monograph is of special interest to surgeons who deal with traumatic injuries of the shoulder, and especially for orthopedists into whose field these lesions frequently fall. The roentgenologist will, by reading this book, obtain much information to enable him to differentiate sometimes very obscure lesions of the shoulder joint.

E. T. LEDDY

BOOKS RECEIVED

FOREIGN BODY IN AIR AND FOOD PASSAGES. By Chevalier Jackson, M.D., and Chevalier L. Jackson, M.D. (*Ann. Roentgenol.*, Vol. 16.) Cloth. Price, $12.00. Pp. 265, with 145 illustrations, New York: Paul B. Hoeber, Inc., 1934.

X-RAY AND RADIUM INJURIES: PREVENTION AND TREATMENT. By Hector A. Colwell, M.B., Ph.D., M.R.C.P., D.P.H., and Sidney Russ, C.B.E., D.Sc., F. Inst. P., The Barnato Joel Laboratories, Middlesex Hospital. Pp. 220. London: Oxford University Press, 1934.

CLINICAL MISCELLANY. The Mary Imogene Bassett Hospital, Cooperstown, New York. Cloth. Price, $3.00. Pp. 206, with 33 figures and 4 colored plates. Springfield, Illinois and Baltimore, Maryland: Charles C Thomas, 1934.

Über die Wirkungen der Röntgenstrahlen auf die Lungen. By Rolf Bull Engelstad. (*Acta radiol.*, Suppl. xix.) Paper. Price, Swed. cr., 9.00. Pp. 94, with 35 illustrations. 1934.

Röntgenologische Studien über die traumatischen und habituellen Schultergelenkverrenkungen nach vorn und nach unten. By Ivan Hermodsson. (*Acta. radiol.*, Suppl. xx.) Paper. Price, Swed. cr., 9.00. Pp. 173, with 15 plates. Lund: Håkan Ohlssons Buchdruckerei, 1934.

Röntgenologische Skelettstudien an menschlichen Zwillingen und Mehrlingen: Ein Beitrag zu den Problemen der Konstitution und der Phylogenese. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, Erganzungsband 46.) By Franz Buschke. Mit Geleitwort von H. R. Schinz. Paper, price M. 25.—; bound, M. 27.—. Pp. 47, with 5 illustrations in the text, and 50 plates. Leipzig: Georg Thieme, 1934.

La négativation électrique: Théorie, premiers résultats, cliniques. By P. Aubourg, Électroradiologiste de l'Hôpital Beaujon, C. Laville, et P. Le Go. Paper. Price, 20 fr. Pp. 146. Paris: Masson et Cie, 1934.

DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., Ph. D., 105 Rutledge Ave., Charleston, S. C.

THE USE OF THE SHEARD-SANFORD PHOTELOMETER IN THE DETERMINATION OF SMALL QUANTITIES OF ROENTGEN RAYS

By EARL I. L. CILLEY,* M.D., *and* EUGENE T. LEDDY, M.D.
Fellow in Radiology, The Mayo Foundation *Section on Therapeutic Radiology, The Mayo Clinic*
ROCHESTER, MINNESOTA

THE PHOTOGRAPHIC method of measurement is in general the most convenient means whereby very small intensities of roentgen rays may be measured directly. The sources of possible error in the use of film in quantitating small intensities of roentgen rays are too well known to be other than mentioned. However, if one uses films from the same lot, both for standard films and test films, and in their exposure takes into consideration the errors in the *Schwarzschild* and the Bunsen-Roscoe "laws," and processes both sets of films at the same time, the results will give a satisfactory degree of accuracy.

In our experiments we exposed dental films of the same lot to roentgen rays generated at 85 kilovolts, and 5 milliamperes, filtered through 0.5 mm. aluminum. With these factors our erythema dose is 400 r (measured in air) at 40 cm. distance. The doses the films received were varied by the inverse square law. These films did not give evidence of as much individual variation as did pieces of 8″ by 10″ film we cut and wrapped ourselves, as they avoided the darkening effect due to pressure, as well as the minute abrasions incidental to cutting and wrapping the pieces of film by hand, both of which artefacts lead to error. With this technique the range of satisfactory blackening ran from 3.10^{-5} to 5.10^{-3} erythema doses when the films were compared grossly.

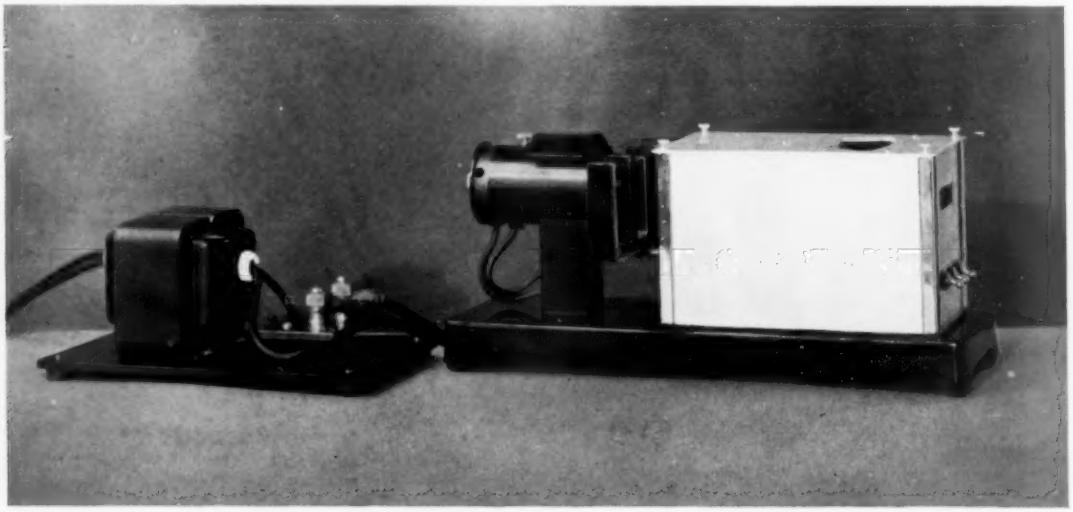


FIG. 1. The Sheard-Sanford photelometer on which the percentage of light transmitted by films of various optical densities was read.

Since the readings obtained grossly were known to have a high degree of inaccuracy

* Now residing in Bellingham, Washington.

we preferred to make the determinations of opacity by means of the Sheard-Sanford photelometer (Fig. 1). This device has in it a constant source of illumination; the light which is transmitted through the object to be measured falls on a photronic (photo-voltaic) cell. The resultant current is read by a micro-ammeter. Since the opacity to be determined is the ratio between the amount of light transmitted by unexposed film and the film under investigation, in the use of the photelometer it is necessary only to place a piece of unexposed film from the group in question between the source of illumination and the photronic cell, adjust the diaphragm so that the micro-ammeter reads 100, and then substitute the standard and test film for the unexposed piece, and compare the readings obtained. Each reading takes from eight to fifteen seconds.

The relationship between the standard erythema doses and the percentages of light transmitted by standard film as recorded by the photelometer are charted in Figure 2. If the values of the opacities of the film as measured by percentages of transmitted light are plotted on semi-logarithmic paper the results shown in Figure 3 are obtained, indicating that the logarithm of the transmitted light bears a linear relationship to the dose. Extremes of density on both the dark and light side cannot accurately be read by the instrument. This is probably due to the inherent limits of the film emulsion.

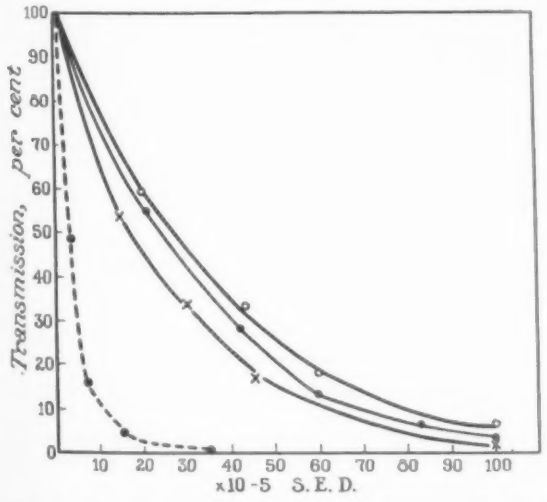


FIG. 2. The relationship between the erythema dose and the percentage of light transmitted by the films.

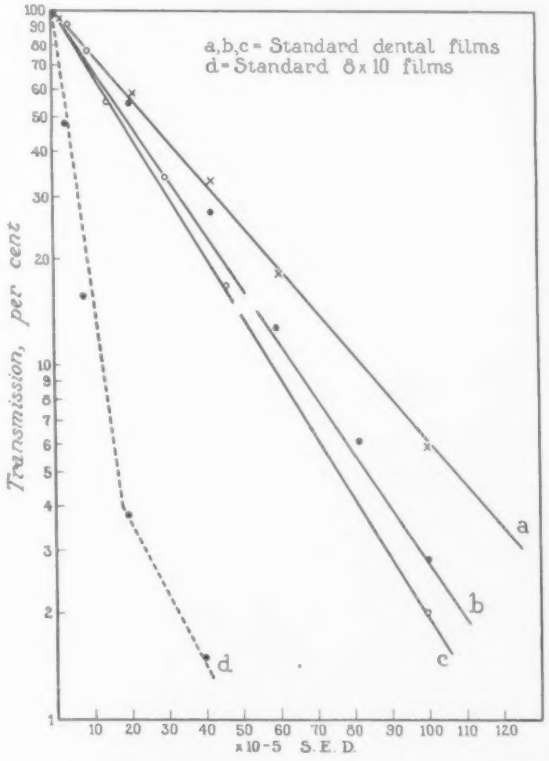


FIG. 3. The relationship between erythema dose and percentage of light transmitted when plotted on semi-logarithmic paper.

Three different types of films which we used in our tests varied markedly in their response to the quantities of roentgen rays in which we are interested. The dental films revealed satisfactory degrees of blackening distinguishable visually over the range of from 3.10^{-5} to 5.10^{-3} of our erythema dose. The duplitized film was much too sensitive (fast), as it became too black to be read readily with doses higher than 8.10^{-4} S.E.D.

The single emulsion 8″ by 10″ special film furnished us by the Eastman Kodak Company showed satisfactory ranges of blackening with doses varying from 2.10^{-5} to 1.10^{-3} of an erythema dose. It is to be understood that in all parts of this experi-

ment the test films we used were developed with and compared with only standard films from the same carton. Thus, the two types of 8″ by 10″ films were developed with and compared to only standard pieces of the same 8″ by 10″ films.

The photelometer, as has been noted, was used only over ranges of opacity considerably less dense than could readily be distinguished visually. Fortunately, the majority of films were of this density.

We have made no attempt to find the lower limit of intensity which can be satisfactorily read with the instrument, but ladders exposed to from 0.00003 to 0.001 erythema doses were easily evaluated (Fig. 4). Between 0.0001 erythema dose (0.04 r) and 0.001 erythema dose (0.4 r) the readings were readily made with a high degree of accuracy and very close agreement of results. In studies of protective devices or of doses received by the personnel of a department of roentgenology it is best to expose the film ladder, regardless of the film used, to known fractions of an erythema dose which will render the film suitably dark to be read in the photelometer, and then trial and error exposures of the test film should be made to give a corresponding density.

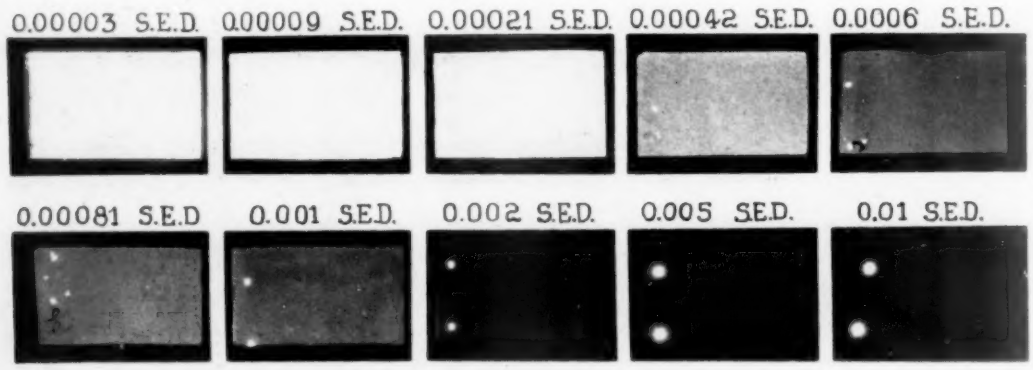


FIG. 4. The type of film ladder read in the photelometer.

Six series of test films were used; each series was exposed to quantities of radiation, varying from 3.10^{-5} to 5.10^{-3} of an erythema dose. Three of these series were composed of dental films and, although developed at different times, revealed very satisfactory ranges of opacity readily measured by the photelometer between the extremes of 2.10^{-5} and 90.10^{-3} of an erythema dose. The duplitized speed film ladder sloped sharply and could be measured for intensities only between 21.0^{-5} and 40.10^{-5} of an erythema dose. The ladders of the specially furnished film were very satisfactory, and likewise agreed well with each other. However, the slope of the line was much less steep than that of the dental films. It might be stated that films exposed to identical doses of roentgen rays gave the same reading on the photelometer if the usual precautions of exposure and development were observed.

From our investigations we feel that since the Sheard-Sanford photelometer is rugged, simple, easy to use, and accurate, it is an important contribution to the precision methods of measuring small quantities of roentgen rays.

REFERENCE

1. SANFORD, A. H., SHEARD, CHARLES, and OSTERBERG, A. E. The photelometer and its use in the clinical laboratory. *Am. J. Clin. Path.*, 1933, *3*, 405–420.

Vol. XXXII, No. 3

A COMPENSATING PANTOGRAPH FOR OBTAINING ACTUAL SIZE TRACINGS OF THE HEART WITH THE ROENTGENOSCOPE*

By GEORGE LEVENE, M.D., FRANK E. WHEATLEY, M.D., *and* HELEN MATTHEWS, M.S.
BOSTON, MASSACHUSETTS

ROENTGENOLOGISTS have always been beset with the difficulty of obtaining actual size tracings of the heart during roentgenoscopic study. Distortion and enlargement of the shadow are due to two factors: the comparatively short tube-screen distance used in these examinations, and the distance of the heart from the screen.

FIG. 1. Showing method of measuring the distance between anterior axillary line and anterior thoracic wall over fifth rib.

Different methods have been devised to overcome this difficulty, the ones chiefly used being teleroentgenoscopy and ortho-

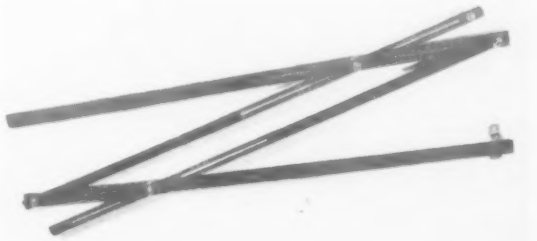


FIG. 2. Compensating pantograph. The arms are adjusted to distance between anterior axillary line and anterior thoracic wall over fifth rib (see Fig. 1).

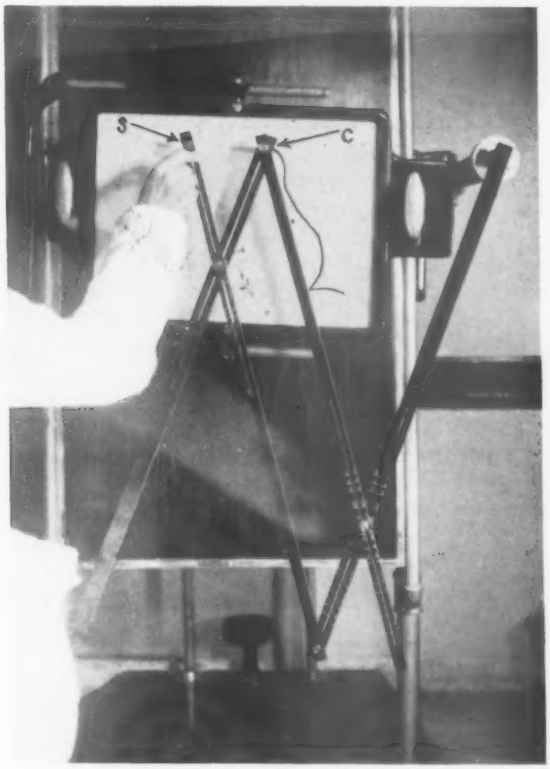


FIG. 3. Compensating pantograph in use. The heart shadow, as it is seen on the screen, is traced with stylus (*S*), while a soft wax crayon (*C*) records the correct image.

* From the Department of Roentgenology of the Evans Memorial for Clinical Research and Preventive Medicine, Massachusetts Memorial Hospitals, Boston.

diagraphy. The former possesses the disadvantage of requiring high energizing tube currents; the latter is a somewhat tedious process where a large number of cases are to be examined.

We have devised a pantograph which corrects the distortion produced at 30 inches for any heart which may be from 1 to 10 inches from the screen and the tracing obtained is identical with the teleroentgenogram of the same heart.

The greatest transverse diameter of the heart (that portion which actually produces the roentgenographic silhouette) is found to lie in the anterior axillary line. It is therefore only necessary to measure the distance between this point and the screen or anterior thoracic wall, over the fifth rib (Fig. 1), and adjust the arms of the pantograph accordingly. The latter are marked in half-inch degrees, corresponding to the distance of the heart from the screen (Fig. 2).

During roentgenoscopic examination, the patient is brought forward until his chest rests against the screen. The roentgenologist quickly traces the heart outline with a brass stylus, while a soft wax crayon draws on the glass of the screen the corrected and actual size of the heart (Fig. 3).

THE LOCALIZATION OF FOREIGN BODIES WITH THE ROENTGENOSCOPE

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TO LOCALIZE radiopaque bodies, the following simple but fairly accurate procedure is outlined.

This method constitutes the viewing of the shadow of the foreign body through the tissues from two directions, and hence, by a simple application of triangulation, of estimating its depth from the surface.

The necessary apparatus consists of a roentgenoscope, a rule of wood, or other transparent material, from 4 to 6 inches in length, two short pieces of wire, and a strip of adhesive tape.

One piece of wire is looped securely about the shaft of the rule over the zero mark on the scale to constitute a fixed marker. The other piece is looped loosely around the rule in such a manner that it may slide along the shaft to form a sliding marker.

Figures 1 and 2 illustrate the two successive positions of viewing the foreign body.

In the first position shown in Figure 1, the shadow of the foreign body is viewed on the fluorescent screen, and the rule, *R*, is so placed that the shadow of the fixed marker, *B*, is superimposed on the shadow of the foreign body, *D*.

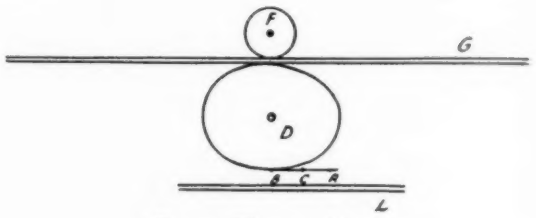

FIG. 1. First position.

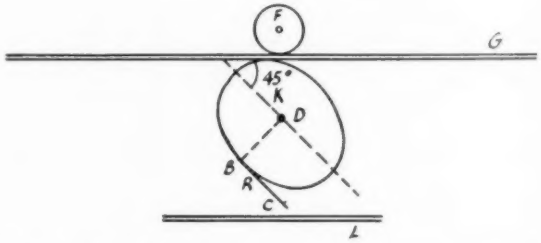

FIG. 2. Second position. *G*, roentgenoscope stand. *F*, roentgen tube. *L*, fluorescent screen. *R*, rule containing fixed marker, *B*, and sliding marker, *C*. *K*, angle of rotation for second observation. *D*, foreign body.

The rule is then fastened securely to the body surface by means of an adhesive strip across its shaft, at the location of the fixed marker, *B*, so that the unsecured end of the

rule containing the sliding marker, *C*, projects at right angles to the line of view in the first position in a direction opposite to that which the body may be rotated for the second observation.

The patient's body is then rotated through an angle of 45° and the shadow of the foreign body is again viewed on the fluorescent screen. The sliding marker, *C*, is manipulated along the shaft of the rule until its shadow is superimposed on the shadow of the foreign body.

The distance of the sliding marker, *C*, from the fixed marker, *B*, equals the depth of the foreign body from the surface at the point of the fixed marker, and may be read directly from the scale on the rule.

By measuring carefully the 45° angle between the two positions, this method may be extremely accurate.

Figure 3 illustrates a sheet of writing paper folded once to form an angle of 45° which may be used as a guide. A dozen measurements by the writer gave, on checking, a maximum error of less than one-quarter inch.

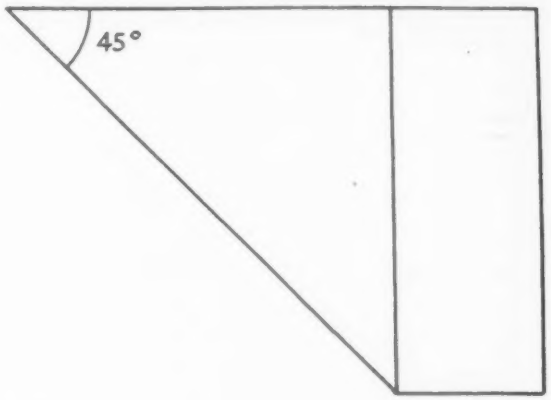

Fig. 3. Folding a sheet of paper to indicate an angle of 45°.

This method may be utilized to localize accurately lung cavities, bone structure, and foreign bodies.

A series of measurements from different points on the body surface is of value in determining the best method of surgical approach.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

ABDOMEN

Sandblom, Philip. The function of the human gallbladder studied in connection with blood transfusions and after stomach operations. *Acta radiol.*, 1933, *14*, 249–258.

Experiments are described which show that during digestion the blood acquires a property which brings about contractions of the gallbladder. This proves humoral evacuation of the gallbladder in man.

The effect of different stomach operations on the evacuation of the gallbladder is also studied and profusely illustrated with roentgenograms. The material shows that the delay in emptying of the gallbladder that often occurs after operations on the stomach takes place whether passage of the duodenum is retained or not. There does not seem to be any reason on this basis for preferring the Billroth I operation. The delay seems to be caused by a delay in the emptying of the stomach and disappears as the motility of the stomach improves. Normal emptying of the gall-bladder seems to be brought about partly by a primary contraction probably initiated from the stomach through a reflex and partly by a secondary contraction initiated from the intestine and probably to a large extent humoral.—*Audrey G. Morgan.*

Kovács, Andreas. Untersuchungen über die muscularis mucosae des Magens. (Studies of the muscularis mucosa of the stomach.) *Acta radiol.*, 1933, *14*, 262–274.

The author made detailed histological examinations of material from the operating and dissecting rooms for the purpose of studying the normal formation of the folds in the mucosa of the stomach and intestine and the histological reasons for changes in its relief under pathological conditions. Photomicrographs of his findings are reproduced. He finds that besides the factors mentioned by Forssell, such as contractions of the muscularis mucosae and muscularis propriae and hydrodynamic displacements in the submucosa, the many elastic fibers in the mucularis mucosae also play a part in the formation of the folds. In the histological specimens these fibers are brought out with special distinctness by the use of Weigert's elastic staining. They form a close network in which the muscle cells are embedded. This reticulum forms an elastic layer which on contraction of the muscle cells, probably at preformed points, rises and pushes the mucous membrane in front of it. If there is interference with the emptying of the stomach or intestine, as in stenoses, increased demands are made on the muscle fibers which may hypertrophy considerably. Gastritis also causes hypertrophy, and severe injury of the muscularis mucosae. Some characteristic gastritic changes in the muscularis mucosae are described such as infiltration, fibrillation, hypertrophy, increase of the elastic cells, formation of lymph follicles, etc.—*Audrey G. Morgan.*

Bonafe and Poulain. Contribution à l'étude des troubles gastriques consécutifs à la phrénicectomie; volvulus de l'estomac. (Contribution to the study of gastric disorders following phrenicectomy (volvulus of the stomach).) *Presse méd.*, July 13, 1932, *40*, 1104–1106.

Phrenicectomy is at the present a routine procedure in the treatment of tuberculosis. The paralysis of the hemidiaphragm results in a marked elevation with compression of the lung on the operated side. It is interesting that in the great majority of the cases this elevation has no effect on the abdominal viscera, at least patients do not complain of any symptoms in connection with these organs. The authors, however, were able recently to observe 2 cases in which the abdominal symptomatology was the direct result of the sequelae brought about by the phrenicectomy. In one of the cases in which there was a very marked gastroptosis the patient complained for a period of six months following the phrenicectomy of a marked epigastric pain, after which time the gastric function as a result of treatment (recumbent therapy and abdominal support) improved although it failed to return to normal. In the second case, the phrenicectomy ultimately resulted in a volvulus of the stomach which was plainly demonstrated three months following the operation. A surgical intervention was rec-

ommended but the patient refused to submit to the operation and at the present time his condition is growing worse.

These 2 cases are interesting because they demonstrate that certain abdominal complications may result from phrenicectomy. Fortunately, they are quite exceptional.—*T. Leucutia.*

Duval, Pierre, and Béclère, Henri. L'insufflation de l'estomac en radiologie clinique (pneumo-gastro radiographie). (Insufflation of the stomach in clinical roentgenology (pneumogastrography).) *Presse méd.*, June 22, 1932, *40*, 981–983.

The insufflation of the stomach is one of the clinical roentgen procedures which gives the greatest service; yet the method is not employed currently. The authors wish to call attention again to its value in various gastric lesions. In fungating cancers insufflation gives information of the first order concerning the protrusion of the mass into the gastric cavity as well as the site of implantation of the cancer. In multiple mucosal polyps it permits the estimation of the number of polyps, often clearly showing the pedunculated appearance. In solitary polyps, the insufflation is not always so valuable but the tumor appears clearly and the base as well as the pedicle is occasionally better demonstrated. In 2 cases of schwannoma the information gained was so remarkable that in one of the cases a preoperative diagnosis could be made. In gastric ulcers the insufflation was occasionally employed with good results, although the authors believe that in this lesion the method is contraindicated.

The technique of procedure consists in making the patient swallow an Einhorn tube and gradually insufflating air into the stomach with an apparatus the pressure of which is well controlled. The procedure is done under roentgenoscopic control and when the patient complains of the slightest pain, air is immediately re-aspirated. The roentgenograms are made standing, in the three positions. In case that a visualization of the bulb is desired the patient is placed in high Trendelenburg position.

The conclusion is reached that insufflation of the stomach is very simple and that it constitutes a valuable roentgen diagnostic method. It should, however, be used only in conjunction with the other standard methods. The article is illustrated with some remarkable roentgenograms.—*T. Leucutia.*

Meyer, Jacob, Fetter, Dorothy, and Strauss, Alfred A. Relation of pain of peptic ulcer to gastric motility and acidity. *Arch. Int. Med.*, Aug., 1932, *50*, 338–347.

Patients were studied in an attempt to demonstrate that acidity or motility, or both, were the cause of peptic ulcer. Varying amounts of 0.5 per cent HCl were introduced into the stomach of patients to note the effect in producing pain. If the acid produced pain the experiment was repeated using water, and it was found in such cases that the water did not produce pain. Rubber balloons were swallowed and used to note whether or not there was any relation between pain and motility. A third set of experiments were done to note the effect of acidity and motility on producing pain.

Results of these experiments showed that hydrochloric acid is not responsible for pain in all cases of peptic ulcer; that pain in gastric and duodenal ulcers may be due to gastric hunger contractions and gastric motility.

Conclusions of the authors were: (1) They believe that the mechanism by which pain is produced by the hunger contractions and motility is a depletion of the vascular bed in and about the ulcerous area resulting in asphyxia, edema, and pain. (2) The positive acid response in cases without intrinsic gastric and duodenal lesions, as in disease of the gallbladder, chronic appendicitis and gastric neurosis, would indicate the unreliability of the "acid test" for gastric and duodenal ulcer. (3) They suggest that the pain in gastric ulcer is due to acid sensitivity when an associated gastritis is present. This same mechanism prevails in cholecystitis, appendicitis, and probably colitis. —*W. C. Hall.*

Buisson, Mario. La diagnosi radiologica dell'ulcera peptica post-operatoria. (The roentgen diagnosis of postoperative peptic ulcer.) *Radiol. med.*, June, 1933, *20*, 743–752.

The author discusses the roentgen diagnosis of postoperative peptic ulcer and concludes that the so-called indirect signs of this condition are of no diagnostic value. The same thing has been found by other roentgenologists with reference to the diagnosis of ulcer of the stomach and duodenum. The only conclusive sign is the direct one of niche of the jejunum and the examination for this must be made with great care. If a large contrast meal is given it passes in a mass through the opening and

hides a niche unless it is a very large one. The paste should be quite liquid and taken in small sips with an interval of several minutes between so as to get diffuse injection of the stomach, the opening and the anastomotic loop. The patient should take a few sips standing and then lie first on his back and then on his abdomen so as to distribute the contrast medium uniformly. Roentgenograms taken in the standing position give the best results. They should be taken in all projections with dosed compression. The compression serves to eliminate pseudo-niches which disappear on compression.

The author emphasizes the importance of infection of the appendix in causing postoperative jejunal ulcer and advocates removing the appendix on the original operation as a preventive measure.—*Audrey G. Morgan.*

GUTMANN, RENÉ-A. Les divers aspects du bulbe ulcéreux. (Various aspects of the ulcerous bulb.) *Bull. et mém. Soc. de radiol. méd. de France*, June, 1932, *20*, 306–320.

By adding the more recently acquired knowledge to the already classic notions, one may distinguish schematically five principal forms of ulcerous bulbs: (1) The inflammatory form characterized by a niche and a localized circle of periulcerous edema. In this form the ulcer as a rule is localized en face, reaching rarely to the external border of the bulb, thus producing no deformity. The lesion develops by inflammatory spells, at which time edematous phenomena lead to internal swelling of the submucosa around the niche with non-filling by the barium of the entire area. These so-called "reserved" spaces to which the barium does not adhere appear in the roentgenograms either in the form of circular halos or more rarely in the form of irregular, clear zones. The inflammatory ulcer is easily demonstrated by the regular technique; in a few instances only is it necessary to resort to special procedures. The roentgen signs appear and disappear with the inflammatory spell. The most unfavorable time for the demonstration of this type of ulcer is during the period of quiescence or during the period which immediately follows the hemorrhage. From a practical standpoint one may say that the diagnosis is possible only during the painful period.

(2) Forms with more marked, more extended and probably more penetrating inflammatory phenomena. In this type of ulcerous bulbs the edema extends farther around the niche, the entire internal surface of the bulb appearing swollen, with ray-like mucosal folds, indicating a very early sclerotic process. The images are rather irregular, due to the fact that the barium penetrates between the edematous areas (the so-called notch or coral-shaped appearance, etc.), and because of the presence of spasmodic phenomena which are of a juxta ulcerous pseudo-diverticular type. It not infrequently happens that one of the spastic images is mistaken for a border niche. The roentgen signs are best demonstrated during the peak of the inflammatory spell; they diminish or disappear with the quieting down of the spell. During the period of quiescence the niche may be absent but the mucosa will always remain irregular and the bulb will show a poor filling; in other words, the bulb will appear abnormal although not showing the characteristic image of an ulcer. From a practical standpoint, in this type of ulcer the diagnosis may be easy during the actual period of the spell but very difficult during the intermediate periods.

(3) Inflammatory forms with parietal sclerosis. The roentgen signs in this type of ulcer are very characteristic whether the ulcer is in an active or a quiescent state (retractions, incisures, organic biloculations, etc.). Furthermore, it is often possible to demonstrate within the sclerotic bulb a more or less typical niche surrounded by edema the amount of which depends on activity of the ulcer. From a practical standpoint one may say that in this type of ulcer the diagnosis is equally easy during the periods of activity and periods of quiescence. The repeated observation of the changes sometimes even permits a diagnosis of "ulcerous attack."

(4) Callus ulcer. This type is rare. The persistence of a niche and external deformations is characteristic. In this form the notion of an "attack" becomes of secondary importance inasmuch as nearly all cases lead to daily pain without periods of sedation. The diagnosis is very easy; there are no periods of "attack."

(5) Forms of parietal and periduodenal sclerosis. In this type the roentgen signs appear, as a rule, quite distinctly but when periduodenitis sets in they become more and more dominated by the picture of this latter. In the simple cases the diagnosis appears easy; in the intermediate cases it is more difficult, but in the extreme cases the aspect of peridoudenitis dominates the picture roentgenologically as

well as clinically, so that the diagnosis of duodenal ulcer is often impossible.—*T. Leucutia.*

Volpe, Vito. Contributo allo studio radiologico dell affezioni morbose del pancreas. (Roentgen study of disease of the pancreas.) *Radiol. med.*, May, 1933, *20*, 592–609.

The roentgen study of diseases of the pancreas is difficult because the pancreas cannot be demonstrated directly. It is possible, however, to obtain a great deal of indirect information from the pressure exercised on other organs. The author discusses the roentgen findings in acute and chronic inflammation of the pancreas, cyst and tumor, describing in detail one case of each with roentgen findings.

Roentgen examination is difficult in acute inflammation of the pancreas because of the pain and the patient's bad general condition. The lateral projection, however, shows the stomach displaced forward and compressed from behind sometimes to such an extent that its contents is divided into two masses, one at the fundus and the other at the lower pole. There are residues of contrast in the stomach and the transverse colon is displaced downward. There is decreased mobility of the left cupola of the diaphragm and sometimes also of the right with a moderate effusion in the corresponding sinus.

In chronic pancreatitis and tumors of the pancreas the findings depend on whether the pathological process is in the head, body or tail of the organ. When the lesion is in the head of the pancreas the duodenum is elongated in a semicircle by the enlargement of the head; the antral part of the stomach is pushed upward and to the left. In chronic pancreatitis the walls of the duodenum show signs of inflammation secondary to the inflammation of the pancreas. The mucous membrane relief is changed and in some cases the design of the valvulae conniventes disappears. Vater's ampulla may also be injected, as well as the beginning of the common duct and Wirsung's duct.

In tumors of the head of the pancreas the median wall of the duodenum may be invaded. In that case a small niche is produced. There is no true filling of the ampulla but it may be invaded by the tumor. If the process is in the body of the pancreas the greater curvature of the stomach shows a filling defect when the patient is lying down which disappears when he stands up. In other cases, there may be pressure on the caudal part of the stomach so that the picture is elongated upward and downward. Another sign is compression of the third part of the duodenum resulting in stasis. There may also be displacement of the duodenojejunal angle which is more marked when the pathological process involves the tail of the pancreas. The transverse colon may also be pushed downward and its diameter decreased. In disease of the tail of the pancreas the most characteristic sign is displacement of the greater curvature of the stomach upward and to the right and downward displacement of the duodenojejunal flexure. In cases of great enlargement of the tail of the pancreas, as in one of the author's cases, there is compression of the first loop of the jejunum which shows only slight barium filling; there is also compression of the median edge of the afferent loop of the splenic flexure of the colon.—*Audrey G. Morgan.*

Gutmann, René A., and Jahiel, R. Les signes radiologiques duodénaux des maladies du pancréas. (The duodenal roentgen signs of lesions of the pancreas.) *J. de radiol. et d'électrol.*, July, 1932, *16*, 307–315.

The secondary changes produced by pancreatic lesions on the neighboring organs have formed the study of detailed reports. Among these, special attention was given to the change produced on the small curvature, on the large curvature, on the antrum and on the colon, but very little was written concerning the changes produced on the duodenum. The authors, in studying these latter, found that they are often of great diagnostic aid. They are classified as follows: (1) disturbances of the passage of the barium, (*a*) partial obstruction, (*b*) complete stenosis; (2) changes of the aspect of the duodenal frame, (*a*) simple enlargement. (*b*) enlargement associated with deformity of the duodenum; (3) images of the duodenal invasion; (4) images of duodenal immobilization; (5) diverticular images appearing within the duodenal frame, (*a*) true diverticula, (*b*) false diverticular images produced through visualization of the ampulla of Vater, and (*c*) cancerous diverticula.

All these changes have only a relative value; in most instances they appear separately, but in doubtful cases they may often lead to a correct diagnosis.—*T. Leucutia.*

MATTHEWS, W. B., DELANEY, P. A., and DRAGSTEDT, L. R. Duodenal tuberculosis; a review of the literature and report of a case of hyperplastic tuberculosis of the duodenum. *Arch. Surg.*, 1932, *25*, 1055–1066.

A list of 123 cases of duodenal tuberculosis compiled from the literature is presented. Many of these, however, may not have been tuberculosis as neither gross nor microscopic confirmation of the diagnosis was always recorded. The authors' case of duodenal obstruction due to hyperplastic tuberculosis with pathological confirmation is presented.

In all the reports the duodenal lesions were merely incidental in the whole picture of advanced terminal tuberculosis. Only 18 cases were found which presented local symptoms. The symptom-complex is identical with that of the common type of duodenal ulcer. A few cases of obstruction of the duodenum due to stricture formation following tuberculous ulcers are mentioned. A duodenal ulcer is more likely to perforate and cause death than ulcers lower down in the intestinal tract. It is suggested that these tuberculous lesions may at first be the common form of duodenal ulcer which subsequently becomes infected with tubercle bacilli. The diagnosis of these tuberculous lesions is seldom made before operation or autopsy.—*J. R. Andrews.*

MUZII, MARIO. Sui segni radiologici della pneumatosi cistica dell'intestino. (Roentgen signs of cystic pneumatosis of the intestine.) *Radiol. med.*, May, 1933, *20*, 660–666.

The author describes a case of cystic pneumatosis of the colon in a man aged thirty who also presented cicatricial stenosis of the pylorus and enormous dilatation of the stomach. A transmesocolic gastroenterostomy was performed by Hacker's method and recovery was uneventful and complete. In connection with this case, the author says that a diagnosis of cystic pneumatosis of the intestine is frequently made on the basis of an abnormal subdiaphragmatic clear space in the roentgenogram. This sign is not sufficient for diagnosis as he has seen it in a number of cases in which there was no cystic pneumatosis. The roentgenogram in his case showed what he calls the rubber sponge picture and without these annular shadows a definite diagnosis of cystic pneumatosis cannot be made.—*Audrey G. Morgan.*

GALLAVRESI, LUIGI. Studio radiologico di morfologia e di fisiologica dell'intestino tenue normale. (Roentgen study of the morphology and physiology of the normal small intestine.) *Radiol. med.*, June, 1933, *20*, 773–805.

This is a collective review of the work done in the roentgen study of the morphology and physiology of the small intestine. The technique used by different authors is described and the appearance of the mucous membrane relief of the small intestine in different stages of digestion and as influenced by changes in peristalsis and tonus is discussed and illustrated by roentgenograms.—*Audrey G. Morgan.*

BABAIANTZ, L., and KADRNKA, S. "Mésentére commun"; étude radiologique. (Mesenterium commune; roentgen study.) *J. de radiol. et d'électrol.*, June, 1932, *16*, 251–260.

After discussing in detail the term of "mesenterium commune" and the embryologic maldevelopment leading to it, and after reporting 3 cases of a similar lesion observed at the Central Institute of Radiology of the Hospital Cantonal of Geneva, the authors make the following conclusions: (1) Mesenterium commune resulting from the lack of torsion or more often from the arrest of torsion of the intestinal loop in embryonal life is characterized by a typical roentgen picture, the signs of which are: (*a*) partial or total dextro position of the third duodenal segment; (*b*) absence of the duodenojejunal angle; (*c*) dextro position of the small intestine; (*d*) sinistro position of the proximal colon of the terminal ileum; (*e*) absence of the hepatic angle; (*f*) formation of a proximal colonic angle which the authors call mesenteric angle (identical with the cephalic angle of Altschul) at the level of the homonymous artery. (2) Mesenterium commune occurs more frequently than hitherto supposed and therefore it is of no little significance from a practical standpoint. Because of the exaggerated mobility of the mesentery it predisposes to rather grave complications such as volvulus and invagination. (3) Without the aid of roentgenology the clinical diagnosis of mesenterium commune is hardly possible due to the fact that the clinical symptomatology is not characteristic. (4) A preliminary complete gastrointestinal roentgen examination is indicated in all cases of abdominal conditions with obscure symptomatology, especially when the question of an abdominal intervention is considered.—*T. Leucutia.*

Sarasin, R. Les solutions colloïdales dans l'examen de la muqueuse du gros intestin. Leur valeur et la technique de leur emploi. (Colloidal solutions in the examination of the mucosa of the large intestine; their value and the technique of their use.) *J. de radiol. et d'électrol.*, Feb., 1933, *17*, 91–97.

Until recently the author used barium suspensions for the exploration of the large intestine, administered chiefly in the form of an enema, but the irregular results obtained induced him to substitute the barium with colloidal solutions. In the beginning, here too great difficulty was encountered in obtaining a uniform distribution of the opaque substance but now the author has constructed an apparatus which permits a very simple and regular administration of the enema. The apparatus has two reservoirs, one containing a pure or a half solution of colloidal thorium and the other a thinner, as a rule one-quarter solution of the same substance. The reservoirs are connected with a gas tank which permits through control of the pressure the administration of the enema in a regulated manner. By change of a foot switch either of the solutions can be injected according to requirement. If a very gentle pressure is applied there is no danger resulting from this method. Several photographs are included illustrating the apparatus, as well as the very uniform distribution obtained in the exploration of the mucosa of the large intestine. —*T. Leucutia.*

Piccinino, Guido. Il disegno di mucosa del grosso intestino in condizioni normali e patologiche. (The mucous membrane design of the large intestine under normal and pathological conditions.) *Radiol. med.*, May, 1933, *20*, 573–591.

Forssell showed that the mucous membrane of the intestine has an independent plasticity and is moulded in different forms depending on the needs of digestion. A diagram from his work is given showing the mucous membrane relief in various phases of digestion. The author has studied the mucous membrane relief of the large intestine under normal and pathological conditions and given roentgenograms showing various typical pictures. The mucous membrane relief can be studied by giving an opaque enema and allowing it to be discharged, leaving only a small residue of barium lining the walls of the intestine. This whole process can be followed by roentgenoscopic examination.

In constipation the author found that transverse folds predominated along the descending colon and sigmoid. In inflammatory processes there was a change in the normal arrangement of the folds with irregularity in distribution and thickening of the folds. These changes were more marked in ulcerous colitis, in acute cases of which there is ulceration and almost total loss of any pattern in the design; in later phases there is an areolar appearance followed by a granular condition. In chronic appendicitis a study of the mucous membrane shows not only direct changes in the appendix but also changes in the mucous membrane relief of the base of the cecum caused by extension of the inflammation to the cecum. Stenotic intestines may be studied by partially evacuating the enema and then insufflating with air. In this way it is possible not only to study the mucous membrane relief but also to determine the extent to which the intestine can distend. The walls are incapable of distention in infiltrating processes. In diverticulitis of the colon the mucous membrane relief is at first normal but finally changes as a result of the inflammation that takes place; it takes on the appearance of an accordeon because of the thickened folds. In invagination there are certain characteristic pictures, such as opaque rings or spirals, onion pictures, etc., caused by the deposition of barium between the transverse folds which clasp the invaginated part of the intestine. Of course, similar pictures are sometimes seen in other conditions, such as in tumors projecting into the lumen and in some disturbances of innervation in which a great deal of gas is produced.—*Audrey G. Morgan.*

Jovin, I., Melinte and Menkes. Imagini lacunare pe caeco-ascendent. (Lacunar images of the ceco-ascendens.) *Bul. Soc. de radiol. si electrol. med. d. Romania*, 1932, *1*, 1–7.

After presenting several cases in the form of brief reports, the authors arrive at the following conclusions concerning the diagnostic value of the lacunar images in the region of the ceco-ascendens. A diagnosis between tuberculosis and neoplasm is very difficult but sometimes possible. An irregular dentated border towards the normal tissues is more typical of tuberculosis, whereas a semicircular sharp outline is more indicative of a tumor. These features are best brought out by an enema associated with

insufflation. Another criterion of differentiation is that in tuberculosis the barium passes more rapidly without arrest at the level of the involved colonic segment. However, according to Stierlin this criterion is not entirely characteristic. It merely proves that there is an atomic lesion of the intestinal wall, a similar appearance being observed in affections of other nature. It is emphasized that the roentgen diagnosis always be coordinated with the clinical findings. This is especially true when the lacunar images appear rather uncharacteristic. —*T. Leucutia.*

KADRNKA, S., and SARASIN, R. Un procédé rapide d'exploration radiologique de l'appendice. (A rapid procedure of roentgen exploration of the appendix.) *Presse méd.*, June 22, 1932, *40*, 990–993.

Afrer the preparation of the patient by purgation (castor oil), the authors proceed with the following technique for the rapid visualization of the appendix. First phase: administration of a barium or umbrathor enema; second phase: spontaneous evacuation of the enema; third phase: insufflation of air. A roentgenoscopic as well as roentgenographic study is made in each of the phases. In a total of 90 cases examined, 66 times the appendix became opacified and 24 appendices remained invisible, 16 of these latter being verified anatomically. Figuring in percentage the authors were thus able to visualize 73.3 per cent of the appendices which is a considerably higher number than that obtained by the usual barium meal (34.9 per cent). This proves that the method is of decided value. It also has the additional advantage that one may study the morphology and the function of the lower portion of the ileum and cecum in general, and of the mucosa in particular, and that it is an exceedingly simple and rapid procedure, the examination being completed in one single sitting. In case of non-visualization of the appendix the examination is repeated if there is cecal stasis to rule out any possible cause of error.—*T. Leucutia.*

KADRNKA, S., and SARASIN. A propos de deux cas de diverticules appendiculaires. Examen radiologique. (Concerning two cases of appendicial diverticula; roentgen study.) *Bull. et mém. Soc. de radiol. méd. de France*, June, 1932, *20*, 321–325.

It is the authors' opinion that appendicial localization of intestinal diverticula is not as rare as is generally assumed. The authors themselves observed 2 cases occurring in a total of 120 examinations, that is, 1.6 per cent. In the first case, that of an aged woman affected with cholelithiasis, the appendicial diverticulum was part of a general diverticulosis, whereas in the second a solitary diverticulum appeared in a young man who for a period of three years suffered from recurring attacks of ulcerous colitis. In none of the cases was the symptomatology typical and no complaints were present in connection with the right lower quadrant. The appendicial diverticula were only incidentally found. Roentgenologically they were characterized by small opaque specks of a rounded form, suspended on the vermicular process and following the movements of this organ during palpation. Their appearance and disappearance was strictly associated with the filling and emptying of the appendix.

Appendicial diverticula may be divided from an etiological standpoint into three groups: (1) those of congenital origin; (2) those acquired as a result of an inflammatory affection, and (3) those of doubtful origin. In the authors' cases the first was no doubt of an acquired nature, whereas in the second the etiology remains uncertain.—*T. Leucutia.*

MICHAEL, PAUL. Tuberculosis of Meckel's diverticulum. *Arch. Surg.*, Dec., 1932, *25*, 1152–1156.

Eight authentic cases of tuberculosis occurring in a Meckel's diverticulum are recorded in the literature. It is seen as a lesion coincident with the disease elsewhere in the body and it complicates and intensifies the general picture of an otherwise simple tuberculous enteritis, precipitating symptoms ending in some acute abdominal crisis. The disease exhibits characteristics of both proliferative and ulcerative processes. Resection is the therapy of election when such a procedure is possible, especially if the condition is complicated further by obstructive symptoms.

The author presents a ninth case in which three pathological and complicating features were encountered, namely, tuberculosis, intestinal obstruction, and perforation resulting in generalized peritonitis. The patient had had right-sided abdominal pain for two years and bloody stools for several months. Physical examination was negative. Roentgenographic

gastric and colon studies showed a constriction in the transverse colon near the hepatic flexure. An exploratory laparotomy was performed and an annular constriction found in that region. The small intestines were enormously dilated. Ileostomy was performed and the patient died five days later. Post-mortem examination showed a diverticulum in the lower part of the ileum in the wall of which were numerous tuberculous ulcers one of which had perforated. Tuberculous lesions were also found elsewhere in the intestine.—*J. R. Andrews.*

Haft, Henry H. The colon changes in chronic arthritis compared with other chronic diseases. *Am. J. M. Sc.*, 1933, *185*, 811–815.

A study of the large bowel in 25 chronic arthritic patients shows a high percentage of ileocecal valve incompetencies, reduplications, lack of haustral markings and atonies. These observations are in accordance with those of Pemberton et al.

A similar study of 25 patients with non-arthritis ailments reveals also a high percentage of reduplications and decreased haustral markings. Ileocecal valve incompetencies and bowel atony are much less frequently found.

The author suggests the presence of abnormalities in the bowels of arthritics as well as in the control cases as a manifestation of chronic diseased states rather than a condition which is peculiar to the chronic arthritides.—*P. J. Hodes.*

Laurell, Hugo. Über reine Coloninvaginationen vor allem vom röntgenologischen Gesichtspunkt. (Pure invaginations of the colon, particularly from the point of view of roentgen examination.) *Acta radiol.*, 1933, *14*, 122–147.

Pure invaginations of the colon, aside from lateral invaginations of the cecocolic type, are very rare and little is known of their roentgen appearance. The author has only found 7 cases in the literature in which a roentgen diagnosis was made. These, together with his own case, are described and illustrated with roentgenograms. In his own case in a man, aged fifty-one, the clinical symptoms were so slight that they did not even arouse the suspicion of invagination. No tumor could be palpated. A roentgen enema, however, showed a tumor defect in the ascending colon and a series of roentgenograms showed the development of an invagination with the tumor as its head and disinvagination when the enema was evacuated. The details of the invagination and disinvagination are shown quite clearly on the roentgenograms that accompany the article.—*Audrey G. Morgan.*

Lupo, Massimo. Un segno radiologico della colite da ameba istolitica. (A roentgen sign of colitis caused by *Entamoeba histolytica.*) *Radiol. med.*, June, 1933, *20*, 709–715.

Four cases of colitis caused by *Entamoeba histolytica* are described in which there was a characteristic roentgen sign which the author calls the "shirt-button" niche. In 3 of the cases *Entamoeba histolytica* had already been demonstrated and roentgen examination showed this characteristic niche; in the fourth the roentgenogram showed the niche and examination of the feces showed *Entamoeba histolytica.* This special form of niche was not found in cases of colitis due to other causes and the author therefore considers it a pathognomonic symptom of colitis from *Entamoeba histolytica.*—*Audrey G. Morgan.*

Weber, Harry M. Carcinoma of the colon: its roentgenologic manifestations and differential diagnosis. *Am. J. Cancer*, Feb., 1933, *17*, 321–341.

Carcinoma is by far the most commonly encountered malignant lesion of the colon. It may be classed morphologically as scirrhous carcinoma (fibrocarcinoma), medullary (polypoid) carcinoma and mucoid (gelatinous) carcinoma. The scirrhous carcinoma develops as an annular cicatrical lesion. Ulceration and extension are not prominent features. The medullary or polypoid carcinoma is usually indistinguishable macroscopically from the benign polypoid lesion. The mucoid or gelatinous carcinoma is a circular, spindle-shaped lesion, the striking feature of which is the tumor mass with denuded, irregular, narrowed lumen of considerable length as compared to the short stricture with little ulceration in fibrocarcinoma.

The opaque meal, the opaque enema, demonstration of mucosal relief, gases as contrast substances and combined forms of methods of investigation of the colon are discussed. A warning is given against using the opaque meal or any combined form of examination employing the meal because of the danger of becoming the immediate cause of an acute intestinal obstruction. The opaque enema is given as the routine method of choice. Its combination with

insufflation of the colon with air ("double contrast" method) is thought by the author to be a very valuable method for demonstrating otherwise obscure, small, non-deforming lesions. It is not recommended as a routine procedure. Experience at the Mayo Clinic on the demonstration of mucosal relief is as yet too limited to permit an expression about its value.

The earliest stage of a malignant process which the roentgenologic method is likely to uncover is the "polypoid lesion." A momentary split in the ascending column of the enema will most frequently be the only indication of its presence. Approximation of the walls of the colon will usually serve to bring out the characteristic contour of the central defect. This lesion, in the author's experience, has been much easier to detect since the advent of the double contrast method.

In the mature carcinoma the filling defect (central or marginal) is the essential roentgenologic sign. The filling defect of the scirrhous carcinoma is short and concentric. Ulceration is usually demonstrable and fixation is rare. The mass sometimes associated with this lesion is usually caused by feces rather than the tumor, which is seldom palpable. In small annular lesions complete obstruction is usually encountered. This is due either to a high grade diminution in caliber of the affected segment or to the establishment of valve mechanism. In polypoid carcinoma the presence of lobulated, cauliflower-like masses projecting into the lumen is characteristic. The filling defect produced by the mucoid carcinoma is longer than that seen in the scirrhous carcinoma. The lumen is irregular and jagged. This tumor is usually palpable.

Filling defects due to carcinomatous lesions of the colon must be differentiated from simple spasm, spasm the result of diverticulitis, local accumulations of gas, fluid, and fecal matter, lesions the result of specific granulomas and rarely lesions the result of chronic ulcerative colitis.—*Leslie Osmond.*

GENITOURINARY SYSTEM

DUMITRESCU, JEAN, and KATZ, TRAIAN. Câteva cazuri de uretrografii. (Some cases of urethrography.) *Bul. Soc. de radiol. si electrol. med. d. Romania*, May, 1932, *1*, 7–13.

The authors used urethrography systematically in a rather large number of cases. They proceed as follows: The patient is placed on a Potter-Bucky table in the Kisch position, that is, either right or left oblique decubitus, forming an angle of 45° with the table. The thigh of the side on which the patient lies is flexed 90° to the pelvis and the leg is flexed on the thigh. The other extremity is straight. This position leads to the best projection of the entire urethral tract. The central ray is centered just above the symphysis.

The authors utilized several solutions but found that umbrathor and thorotrast have a great advantage over the oily iodipin or lipiodol, in that they mix with the fluids which eventually accumulate in diverticula or cavities of the anterior and posterior urethra and especially with the residual urine in case of cysto-urethrography. The solutions employed were diluted with an equal amount of water. The method being entirely painless, no preliminary anesthesia is necessary. The technique of injection depends on whether the anterior or the posterior portion of the urethra is examined. In the first it is generally agreed that after all the above preparations are completed, the assistant grasp the glans penis between his left index and middle finger and injects with a gentle pressure an opaque solution varying between 10 to 20 c.c. When the sensation is obtained that the anterior urethra is sufficiently distended a roentgenogram is made. In the second, the opinions are somewhat divided and there are now two procedures which are followed. These refer chiefly to the time of the actual roentgenogram, some advocating that it be made during the actual urination, the bladder being preliminarily filled with the opaque solution, whereas others prefer the taking of the roentgenogram during the actual injection under a mild pressure. The authors are in favor of this latter procedure which they add to the urethrography of the anterior portion of the urethra. Thus after they have injected 10 to 20 c.c. of the solution into the anterior urethra they continue the injection of another 10 to 20 c.c. of the solution by taking the roentgenograms during the actual time of injection.

The method is of value especially in visualizing the following conditions: strictures, urethral and prostatic calculi and foreign bodies, deviations and anomalous development of the urethra (paraurethral canals, double urethra), fistulous tracts, diverticula, sacciform and cavernous formations of inflammatory nature

and finally in the visualization of the adnexal glands of the anterior and posterior urethra. Six rather unusual cases are briefly reported. —*T. Leucutia.*

Braasch, William F. The practical application of excretory (intravenous) urography. *J. Am. M. Ass.*, 9, 1933, *101*, 1848–1852.

The members of the medical profession have been inexcusably slow in availing themselves of the opportunities of diagnosis of abdominal lesions by excretory urography. The attitude of urologists is changed completely and now there are a few who claim the cystoscope is no longer necessary in the diagnosis of renal lesions.

Diagnosis will be improved as deformities are standardized. Excretory urograms will be of value to clinicians in determining the presence of stasis in the pelvis or ureter, aiding in interpretation of shadows in the upper urinary tract, and in estimating renal function. Diagnosis may be made difficult by incomplete filling, delay in filling or emptying, or difference in filling of the two sides, necessitating experience and care in interpretation.

Excretory urography is of special value in hydronephrosis, renal ptosis, lithiasis, tuberculosis, as well as in abdominal tumors. It is also useful in special investigation of stricture, angulation, postoperative injury or cystic retention. It is invaluable in cases which cannot be cystoscoped or have ureteral catheterization but in only a limited field will it entirely replace other urologic data.—*E. W. Hall.*

NERVOUS SYSTEM

Radovici, A., and Meller, O. Encefalomyelografia liquidiana. (Liquid encephalomyelography.) *Bul. Soc. de radiol. si electrol. med. d. Romania*, June, 1932, *1*, 1–8; October, 1932, *1*, 2–9; December, 1932, *1*, 5–9; *Presse méd.*, Dec. 21, 1932, *40*, 1933–1938.

On March 1, 1932, the authors presented before the Academy of Medicine of Paris for the first time their procedure which they call "liquid encephalomyelography." The principle of the procedure is that an opaque solution is injected into the cerebrospinal fluid which by mixing with the fluid outlines the surface of the brain or of the spinal cord. After numerous experiments the authors found that colloidal thorium (thorotrast) is the most suitable substance, an injection of 5 to 10 c.c. leading to a solution which is opaque enough to give satisfactory roentgenograms.

The injections were first carried out in rabbits, dogs, cats and monkeys, and on a few human cadavers. After a satisfactory technique was elaborated, it was finally attempted in living humans. First a demented person suffering from general paralysis was injected by the lumbar route, the dose being progressively increased from 1 to 5 c.c. It was found that the doses from 3 to 5 c.c. provoked marked thermic reactions, reaching as high as 39° Celsius for a dose of 5 c.c. Within a few days everything returned to normal but the authors were reluctant to further increase the dose for fear of producing more accentuated meningeal reactions. Unfortunately with a maximum dose of 5 c.c. not a sufficient opacity was obtained for good roentgenograms. The method was then tried in an idiot child three and a half years of age by again injecting 5 c.c. thorotrast by the suboccipital route. Here a good visualization of the tissues was obtained. Immediately following the taking of the roentgenograms a lumbar puncture was done and 30 c.c. cerebrospinal fluid evacuated to get rid of as much of the injected thorotrast as possible.

The conclusion is reached that the method is not as yet entirely practical. The meningeal reaction and the thermic elevation must be considered injurious. Furthermore it is necessary to immediately evacuate as much as possible of the injected substance by an aspiration of the cerebrospinal fluid to forestall a later absorption of the thorotrast by the reticuloendothelial system which occurred in most of the experimental animals. It seems so far that the method could be applied in case of definite diagnosis of brain tumor for the more exact localization of the site of the tumor, it being understood that the solution is withdrawn immediately following the taking of the roentgenogram by performing decompression or other type of brain operation which may appear necessary.—*T. Leucutia.*

Egas Moniz, Abel Alves and Fernando de Almeida. La visibilité des sinus de la duremère par l'épreuve encéphalographique. (The visibility of the sinuses of the dura mater by the test of encephalography.) *Presse méd.*, Oct. 5, 1932, *40*, 1499–1502.

More recently the authors employed thorotrast (in the form of a 25 per cent colloidal suspension of ThO_2) in intracarotid injections

for cerebral arteriography. Because of the insolubility of this substance in the blood and because of the slight slowing down of the circulation of the blood which it brings about, the authors conceived the idea of making delayed roentgenograms for the demonstration of the veins of the brain. Indeed, by making a second exposure two seconds after that made for cerebral arteriography, they were able to demonstrate the venous plexus, the arterial injection having already disappeared. These second films are called the first phase of cerebral phlebography. By taking a third roentgenogram two to three seconds later one finds that the opaque substance has already entered the venous circulation of the meninges and of the soft tissues of the cranium. This then is called the second phase of cerebral phlebography. For a while it was impossible to make a roentgenogram of the superior and longitudinal sinuses but after following the experimentation the authors succeeded in visualizing these vessels as well. For this purpose they have increased the initial quantity of thorotrast which is injected into the common carotid, at the same time injecting the solution very rapidly, as a rule within two seconds. The procedure is then as follows: After the patient is prepared and the injecting needle inserted into the common carotid according to the established technique, the thorotrast is injected from a 20 c.c. syringe. When a quantity of 13 to 14 c.c. is already injected, the first film is taken instantaneously for cerebral arteriography, then the injection is continued with the same speed until 17 to 18 c.c. of the thorotrast has been injected and immediately a second film taken which is four to five seconds after the first. In this manner the venous sinuses are visualized in most of the roentgenograms. The authors use several films made on cadavers and on the living to illustrate the value of their procedure.

To obtain a good demonstration of all phases of the arteriovenous cerebral circulation, it is best to make successive serial films. An automatic device permitting six instantaneous roentgenograms in the shortest time possible would be of great value. In this manner the first roentgenogram would be for arteriography, the second two seconds later and the remaining four at intervals of one second each would serve to demonstrate the entire venous circulation of the brain meninges and soft tissues of the cranium. This procedure would also permit a study of the variation of the speed of the circulation depending on the cardiac state of the patient as well as the study of the action of various drugs on the circulation in general and on the brain in particular. The use of thorotrast in over 100 cases so far has proved that the method is entirely innocuous even with elevated doses.—*T. Leucutia.*

VITEK, JIRL. Nouvelle méthode décompressive et évacuatrice de la cavité syringomyélique par ponction faite à son pole inférieur; ponction bipolaire de la cavité syringomyélique. (New decompressive and evacuating method of the syringomyelic cavity by puncture made at its lower pole; bipolar puncture of the syringomyelic cavity.) *Presse méd.*, Oct. 5, 1932, *40*, 1507–1508.

In 1927 the author for the first time did a puncture of the syringomyelic cavity for therapeutic purposes, replacing the operation of Puusepp which, as is known, has the purpose of decompressing the spinal cord over the syringomyelic area. To make sure that the needle is within the syringomyelic cavity and not within the spinal canal, the author injected lipiodol into the cavity, this procedure being called "endomyelography" by Jirasek who had already employed it in a number of cases. Jirasek has established a principle of opening the syringomyelic cavity at its lower pole to satisfy the conditions of hydrostatic pressure, the laminectomy being likewise performed in this region (modification of Puusepp's operation).

The above procedure, in addition to permitting a good roentgen visualization, leads to good palliative therapeutic results. It must be mentioned, however, that the administration of roentgen therapy is still the principal and most efficacious procedure in treating syringomyelia. Endomyelography may be successfully used for the control of the results of roentgen therapy.—*T. Leucutia.*

SKELETAL SYSTEM

CAMPLANI, MARIO. Sopra un caso di sifilide scheletrica plurisegmentaria verosimilmente ereditaria tardiva. (A case of syphilis of various bones, probably one of late congenital syphilis.) *Radiol. med.*, 1933, *20*, 1009–1021.

The author describes a case in a young woman aged twenty. Her mother had had treatment for syphilis. She had two sisters and a brother all well and with negative Wassermann reactions. She herself had always been defective in development. She weighed only 75 pounds

and had never menstruated. About six years ago she began to have pain in the bones, chiefly at night, particularly in the shoulders. Treatment with iodide had little effect. On admission to the hospital in a very weak condition her blood Wassermann reaction was strongly positive. Reaction in the spinal fluid negative. There was irregular protrusions of the skull in the parietotemporal regions but not a typical Olympian forehead. She did not have a typical saddle nose or Hutchinson teeth. The right shoulder was painful on pressure and also the right knee which was fixed in partial ankylosis. The femurs were enlarged and there was a pain point in the right tibiofibular region.

Roentgen examination showed the bones of the skull worm eaten. Zones of erosion alternated with zones of new production of bone. The diaphyses of the long bones were swollen and it was hard to differentiate between the cortex and marrow. Here, too, zones of rarefaction alternated with those of intense opacity. Evidently a destructive process alternated with exuberant reproduction. There were no osteophytes. The bones of the hands and feet were normal.

The patient was placed on bismuth, arsenic and iodide treatment and improved rapidly. The pain stopped, she gained weight and menstruation began. Her Wassermann reaction remained positive however. At the end of a year she weighed 115 pounds. Roentgen examination showed improvement in some of the bones while others were unimproved.

It is impossible to make a differentiation between tertiary acquired syphilis and late congenital syphilis by means of roentgen examination but this was probably a congenital case. —*Audrey G. Morgan.*

Goldstein, D. W. Syphilitic bursopathy of Verneuil. *J. Arkansas Med. Soc.*, July, 1932, *29*, 56–58.

The thirty-ninth recorded case of syphilitic bursitis is reported, involving the common sites of the prepatellar and subpatellar bursae symmetrically. There was prompt response to antiluetic therapy. Roentgenology with lipiodol injection was employed as an aid in diagnosis. The injection was given through the skin which was attached and demonstrated that there had been a diseased process of the bursae. It is almost impossible to inject a normal bursa from without. Roentgenograms and clinical photographs illustrate the article.—*W. R. Brooksher.*

Hitzrot, Lewis H., and Comroe, Bernard I. Hyperparathyroidism with parathyroid tumor; report of a case improved by partial parathyroidectomy. *Arch. Int. Med.*, Aug., 1932, *50*, 317–327.

An example of clinical hyperparathyroidism without demonstrable parathyroid pathology is reported. The patient had all of the symptoms of the disease, an extensive decalcification of the skeleton and muscular weakness, and abnormally high blood calcium with an excessive daily calcium output. Apparently normal parathyroid glands were removed at two different operations. The clinical picture began to improve following the second operation, and later tetany developed. This was easily controlled and in twenty-two weeks after admission the patient was able to resume her household duties. The case reported differs from those usually cited in that no gross or microscopic abnormality was detectable in the gland removed, yet the therapeutic result was excellent. —*J. H. Harris.*

Schiassi, Francesco. Osteoartropatia ipertrofica pneumica per metastasi ossea di cancro del polmone. (Hypertrophic pneumic osteoarthropathy due to bone metastases from cancer of the lung.) *Radiol. med.*, June, 1933, *20*, 753–772.

A case is described in a woman of sixty-six who died from cancer of the lung. About eighteen months before her death she began to suffer intense pain in her limbs which grew so much worse that she was bedridden and had to be given opiates to control the pain. The bones of the hands and feet and the wrist and ankle joints were greatly enlarged and the fingers were hippocratic. The patient showed a masculine type of hair. Her photograph, reproduced in the article, looks like that of a man. Histological examination of the bones showed a mantle of new-formed bone beneath the periosteum around the old bone. Between the compact bone of the diaphysis in the long bones and the new-formed bone there was a transparent line of decalcification. The flat bones showed extreme decalcification. The author concludes that this hypertrophy of the bones was caused by a subperiosteal metastasis from the tumor of the lung. Marie has described such bone changes and called them

"pneumic," meaning derived from the lung. Metapneumopathic would be a more accurate designation.—*Audrey G. Morgan.*

ELLIOTT, ARTHUR R. Renal rickets. *J. Am. M. Ass.*, March 11, 1933, *100*, 724–725.

A case of rickets developing in childhood and associated with chronic urinary infection is reported, with comments on 84 cases collected from the literature. This case had symptoms beginning at four years of age and was observed from the age of eleven to her death of uremia at twenty-four. The chief evidence of rickets was a marked genu valgum which caused great difficulty in walking. The epiphyseal lines of the long bones were widened, irregular, hazy and rarefied and there was irregular widening of the diaphyses.

Chronic nephritis, renal insufficiency, congenital cystic kidney and double hydronephrosis are also possible causes of renal rickets. Dwarfism, sexual infantilism and azotemia are usual in marked cases and the characteristic signs of rickets are seen roentgenographically. Genu valgum may be the first symptom to call attention to the kidney condition.—*E. W. Hall.*

WINDHOLZ, FRANZ. Über familiäre Osteopoikilie und Dermatofibrosis lenticularis disseminata. (On familial osteopoikilosis and dermatofibrosis lenticularis disseminata). *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1932, *45*, 566–582.

An association of osteopoikilosis with a peculiar condition of the skin was first described by Buschke and Ollendorf in 1928. They observed in a woman forty-one years of age who was of an infantile build, an involvement of the skin of the shoulders, lower abdomen, gluteal region and both thighs, consisting in a net-like arrangement of lentil-sized, rather regular prominences. Microscopically there was evidence of a fibrous thickening of the cutis without the characteristics of tumor formation and with maintenance of the elastic fibers. The condition was called "dermatofibrosis lenticularis disseminata" and the opinion was expressed that its association with osteopoikilosis was not merely the result of coincidence but of a definite interdependence.

The author observed an identical condition occurring in 3 cases, 2 of which belonged to the same family: the first, a man forty-six years of age, with typical changes in the skeleton and skin, the second a daughter, 10½ years of age, with the same findings in the skeleton and skin but with an additional sexus anceps, and the third case, a boy aged nineteen, with roentgenologic and dermatologic findings similar to the first two, except for the fact that parallel stripes of bone density such as described by Voorhoeve were observed in the metaphysis of one of the lower femurs. The cases are described in detail and illustrated with numerous roentgenograms showing the bone changes, and several photographs illustrating the skin condition. Comparative histologic investigations revealed that the foci of osteopoikilosis were the result of islands of compact bone, showing normal osseous structure, whereas the skin changes were the result of fibrotic changes of the cutis such as described by Buschke and Ollendorf. It is the author's opinion that there is a definite morphogenetic analogy between the changes of the skeleton and skin. Furthermore, the fact that the condition occurred in father and daughter indicates a hereditary tendency. It is not yet proved whether external factors have any influence on the manifestation of the anomalies described.—*T. Leucutia.*

MARINESCO, G., and ALLENDE, GUILLERMO. Sur une forme nouvelle de rhumatisme chronique fibreux; rhumatisme chronique familial et infantile. (On a new form of chronic fibrous rheumatism; chronic familial and infantile rheumatism.) *Presse méd.*, April 27, 1932, *40*, 646–649.

The "dismemberment" of "chronic rheumatism" which started with the work of Landré-Beauvais over a century ago has continued up to the present time. New forms were broken away from the mother group which, in the light of acquired knowledge, were considered and classified as separate entities. The authors, during their scientific mission in Argentina, encountered articular deformities occurring in two brothers and one sister which could not be placed with any of the hitherto known groups. Therefore they wish to create a new group calling it "chronic familial and infantile progressive rheumatism." A review of the literature revealed that this condition must be quite exceptional inasmuch as only one author, Capite of Italy, described a somewhat similar lesion which occurred in 3 members of the same family (2 brothers and 1 sister). In the authors' cases the condition was observed in the second (6½ years old), third (5½ years old) and fourth (3½ years old) child of the same family, the

first child (10 years old) having remained entirely free of the disease.

The chief characteristics were the homochrony, the onset being at the age of ten months and the homotopism, the lesions being localized to the same system and articulations. The homotopism was so pronounced that photographs, which are included, showed a nearly identical appearance in all three children.

The case histories, clinical and roentgen findings in all 3 cases are given in lengthy detail, several roentgenograms being used for illustration. In summarizing, the disease commenced at the early age of ten months, with gastrointestinal disorders and attacks of fever and general debility. Soon afterwards tumefactions of the joints appeared, of the wrists and knees first, and of the other articulations later. The children started to walk later than usual. The disease continued at a slow rate, however without further signs of infection or fever. The roentgen examinations showed marked decalcification of the epiphyses, but no osteophytic proliferations. In the oldest child there was a narrowing of the joint space but in the others the joints involved appeared fairly normal. Somatic measurements revealed a comparative shortening of the forearms and hands with marked decalcification of the bones, especially of the phalanges.

Differential diagnosis from Still's disease was based on the absence of adenopathy, splenomegaly, leucocytosis, and anemia, and on the early onset (Still's disease occurring between the ages of two and six years). A further differential criterion was the clinical course, Still's disease usually terminating fatally with repeated spells of high fever and digestive symptoms.

In considering the etiology, the authors state that the possible involvement of the thyroid gland might be admitted on a theoretical basis. There was, however, no definite clinical proof to support it. The Wassermann and von Pirquet reactions were negative, eliminating syphilis and tuberculosis. The possibility of a *Streptococcus viridans* infection, which is so much emphasized lately by American authors, is also to be considered.—*T. Leucutia.*

Simon, René, and Weill, Joseph. Opérations sur la région des parathyroïdes et rhumatisme déformant. (Operations in the region of the parathyroids and deforming rheumatism.) *Presse méd.*, March 16, 1932, *40*, 412–414.

Opel and Leriche successfully applied parathyroidectomy in a number of cases of chronic deforming rheumatism. Both of these authors establish their operative indications on the basis of the total calcium content of the blood. But Opel operates on all cases with a calcium content above 105 mg. per 100, whereas Leriche does not intervene unless the blood calcium is above 110 mg. per 100. The authors, in studying the observations of Opel and Leriche, were surprised to find that favorable results were often obtained when the histologic examination of the removed tissue failed to elicit the presence of parathyroid, consisting only of a simple thyroid gland tissue or fragment of fat. They found a similar prompt amelioration in two of their own cases of chronic deforming rheumatism in which only a sham parathryoidectomy was performed. These two cases are described in great detail. In the first, the surgical intervention was limited to incision, examination of the parathyroid region and closure of the wound; in the second, a small lobule of the normal thyroid gland was removed without preliminary ligation. In both cases the amelioration started soon after the operation (June 8, 1931, and June 26, 1931, respectively) and continued afterward. It is also interesting that the respective blood calciums in the two cases were 82 and 92 mg., that is, considerably lower than the required minimum of Opel and Leriche, indicating that hypocalcemia does not form a contraindication for surgical intervention in chronic deforming rheumatism.

The problem needs further investigation. For the present it seems that there exists a surgical treatment of chronic deforming rheumatism which is more intriguing than that of parathyroidectomy. This consists of a facsimile operation which leads to excellent results without depriving the patient of any of his essential glands.—*T. Leucutia.*

Wetherby, Macnider. Chronic arthritis; a clinical analysis of 350 cases. *Arch. Int. Med.*, Dec., 1932, *50*, 926–944.

Wetherby based his study on 350 consecutive cases of arthritis seen in the out-patient department of the University of Minnesota Hospital. He defines arthritis as a disease probably of infectious origin and believes that the evidence points strongly toward the streptococcus as being the causative agent in the majority of cases, including the cases termed acute rheumatic fever as well as chronic arthritis.

Other organisms are causative in occasional cases.

Of the 350 cases 70 per cent were women; the age of onset for both men and women was generally the fifth decade; the joints most frequently involved were knees 83 per cent, fingers 61 per cent, ankles 58 per cent, spine 57 per cent, shoulders 57 per cent, wrists 50 per cent, hips 45 per cent, and elbows 43 per cent. In 13 per cent of the cases there was a history suggestive of rheumatic fever but, clinically, the author was unable to place a sharp dividing line between cases termed rheumatic fever and those with an apparently similar onset that progress to chronic articular involvement. Probable sources of streptococcic infection were known to precede the arthritis in 30 per cent. The most common inciting sources were dental infection, sinusitis, acute respiratory infection, tonsillitis, puerperal infection, and the puerperium. Subcutaneous nodules were present in 31 per cent. Roentgen examination of painful joints in 60 cases showed a pure type of involvement in only 33 per cent, mixed in 58 per cent, and no positive findings in 8 per cent. In certain joints, as in the shoulder, atrophic changes are present in nearly all cases while in the knee hypertrophic changes are more commonly present. The age of the patient, the duration of symptoms, and the joint examined are important factors in the roentgen interpretation.

Removal of alleged foci of infection, especially teeth, tonsils, and sinuses; intravenous typhoid vaccine; medication; physiotherapy; and dietary treatments had been of little value in the previous treatment of these cases.

On the basis of the clinical and etiologic evidence, it seems likely that streptococcic infection is responsible for the majority of the acute and chronic infections of the joints, such as rheumatic fever, rheumatoid arthritis, and osteoarthritis. Cases to be excepted are senescent, traumatic, post-hemorrhagic changes, and those due to other specific infectious agents.—*J. R. Andrews.*

GOLDHAFT, ARTHUR D., WRIGHT, LILLIE M., and PEMBERTON, RALPH. The influence of age in the experimental production of hypertrophic arthritis. *Ann. Int. Med.*, June, 1933, *6*, 1591–1598.

The authors base their investigations on the following clinical observations: (1) atrophic arthritis is found, as a rule, earlier in life than hypertrophic arthritis; (2) it is not rare to find atrophic joints taking on characteristics of hypertrophic arthritis with age. These facts lead some students to suspect that hypertrophic arthritis appears at mid-life because of the differing response of the tissues consequent upon some factors, such as arteriosclerosis, or its vascular precursors which are present, in greater or less degree in all humans or animals that reach that age.

In previous experiments, by the authors, on old dogs, there was a definite suggestion that interference with the blood supply produced changes characteristic of hypertrophic arthritis. These same experiments were repeated upon young dogs. Interference with the blood supply to the knee joints in these animals is not accompanied by the changes found in the older dogs. In light of these findings the authors infer that the phenomena of hypertrophic arthritis may represent a response due to the particular conditions of the tissues rather than the effect produced by the action of any type-specific etiologic factor.—*P. J. Hodes.*

MILCH, HENRY, and BURMAN, M. S. Snapping scapula and humerus varus. *Arch. Surg.*, April, 1933, *26*, 570–588.

Scapular grating, snapping, and crepitus have been described by many authors. Such sounds are in the main confusing only in the examination of the chest and are only rarely accompanied by symptoms or morphologic variation. The causes of these sounds may be divided into four main groups: (*a*) those due to changes in the bony structure of the undersurface of the scapula, or of the wall of the chest; (*b*) those due to changes in the musculature intervening between the scapula and the wall of the chest; (*c*) those due to changes in the bursae normally or abnormally present between the scapula and the wall of the chest, and (*d*) those incapable of classification in the preceding groups because of a lack of knowledge of the mechanism of production or of the underlying pathology.

Six cases are reported, most of which secured relief by various physical therapeutic methods. The case of a girl aged eighteen is reported in whom there was snapping in both shoulders and pain in the left shoulder following a fracture of the clavicle three years previously. Roentgenograms showed a malunited fracture of the left clavicle with bilateral forward curvature of the superior scapular edge and

marked varus of the humeral head. Resection of the supraspinous portion of the scapulae was followed by complete relief.

Other cases of varus of the humeral head are described. Some appear to be congenital, others are associated with constitutional dystrophic disorders, tumors, and Gaucher's disease, and a few are associated with bone cysts of the proximal end of the humeral diaphysis. As these conditions are generally symptomless, except where pathological fracture may occur, produce no limitation of motion, and give no discrepancy in the relative length of the arm, they require no treatment.—*J. R. Andrews.*

Hellmer, Hans. Ein Fall von Verlagerung von Bandscheibengewebe nach hinten. (A case of backward dislocation of intervertebral disc tissue.) *Acta radiol.*, 1933, *14*, 165–171.

A man aged sixty came for examination complaining of loss of sensation of the soles of the feet and back of the legs and around the anus. Roentgen examination showed the intervertebral disc between the 10th and 11th thoracic vertebrae decreased in thickness. No definite diagnosis was made and as the symptoms were not serious the patient was discharged. The symptoms grew worse and pain in the calves developed. Lipiodol examination showed a structure, apparently cartilaginous in nature, on the posterior surface of the intervertebral disc, pushing the spinal cord backward. Operation confirmed the finding. The intervertebral disc was either displaced backward or a chondroma had developed on its posterior surface which exercised pressure on the cord at this level. The previous work on the subject is reviewed, particularly that of Schmorl.—*Audrey G. Morgan.*

Smith, Alan DeForest. A benign form of osteomyelitis of the spine. *J. Am. M. Ass.*, July 29, 1933, *101*, 335–337.

Osteomyelitis of the vertebral column is more common than is usually supposed. The author reports 17 cases occurring between 1924 and 1932. Many cases are, contrary to the usual belief, mild and of this series 7 were of such low grade that a diagnosis of tuberculosis had been made. In 14 of these cases the bodies were involved, in 3, the arches. In the clinical diagnosis important features are: history of pyogenic infection elsewhere, sudden onset, pain of varying intensity and not relieved by rest, fever, and kyphosis, these being usually, though not always, present. The blood count usually shows a polymorphonuclear leucocytosis. The roentgenogram shows at first a haziness, then narrowing and destruction of the intervertebral disc, followed by destruction of bone, this being less than in tuberculosis and a tendency toward bony overgrowth with ankylosis.

The cases that have been treated conservatively seem to have fared better than by radical methods. Conservative treatment should be given a thorough trial before operative treatment is instituted.—*E. W. Hall.*

Holbrook, W. Paul, Stecher, Robert M., and Hayden, Edward M. Primary spondylitis. *Ann. Int. Med.*, 1933, *6*, 1327–1334.

Three hundred patients with chronic arthritis were studied from the research and clinical viewpoints, the observations continuing over a period of five months with careful inquiry into history, physical examination, laboratory findings, roentgenologic studies and response to treatment. Without assuming any specific etiology, these have been classified into six groups. Under group IV are included 22 cases of primary spondylitis, occurring only in males. Two specific types of this disease were noted. The first type does not present bony bridging and appears to be an unrecognized syndrome. The spines become completely stiff without demonstrable roentgenologic findings. The second type is characterized by stiffness of the spine associated with bony bridging between the vertebrae, local or generalized to include the entire spine.—*W. R. Brooksher.*

Junghagen, Sven. La pneumographie du genou, surtout sans des cas de lipoma arborisant. (Pneumography of the knee, particularly in arborizing lipoma.) *Acta radiol.*, 1933, *14*, 172–183.

Three cases of arborizing lipoma of the knee-joint and one of cyst are described. Roentgenograms were made by the ordinary methods and after insufflation of air into the joint. The roentgenograms taken without insufflation of air showed only the ordinary picture of arthritis deformans but those taken after the insufflation of air showed a very characteristic pathological picture. The cases are illustrated with roentgenograms and photographs of the pathological specimens. The method of insufflation of air into the knee-joint is of great value and absolutely harmless.—*Audrey G. Morgan.*

FRANCISCO, CLARENCE B. Tumors of the pelvic bones. *J. Am. M. Ass.*, Nov. 26, 1932, *99*, 1845–1849.

Benign tumors of the pelvic bones are rare. The pelvis is a common site of malignant metastases and a not infrequent site of primary bone sarcomas and chondromas. Chondromas should always be treated as malignancies which will probably metastasize and should therefore be resected early whether signs of malignancy are present or not. Bone sarcomas are better managed by radiation therapy than surgery although few five year cures are reported. The prognosis of pelvic bone tumors cannot be predicted with any degree of certainty.—*E. W. Hall.*

LANG, F. J., and HASLHOFER. Changes in the symphysis pubis and sacroiliac articulations as a result of pregnancy and childbirth. *Arch. Surg.*, Nov., 1932, *25*, 870–879.

Roentgenographic studies, horizontal sections and histological studies of cross-sections and of the joints at the end of pregnancy and shortly after labor place on an anatomic basis the clinically recognized gaping of the pelvis in pregnancy and labor. They show the development of this widening and the alterations that pelvic joints suffer. These alterations are characterized by minute areas of damage, microscopic fractures, fissure and cyst formations and hemorrhages in the symphysis pubis and sacroiliac joints. These findings indicate that pregnancy and labor, with their disturbances of the static mechanical relationships of the pelvis, are not inconsequential factors in the etiology of arthritis deformans.—*Leslie Osmond.*

BOZZETTI, GIUSEPPE. Esiti a distanza di cisti ossee solitarie giovanili operate. (Late results of operation in solitary juvenile bone cysts.) *Radiol. med.*, June, 1933, *20*, 725–743.

Four cases of solitary bone cysts in young persons fourteen, fifteen and sixteen years of age are described. These are not true cysts as shown by the fact that they have no cellular membrana propria. They were spindle-shaped and made up of a thin involucrum of bone containing a hemorrhagic fluid. They gave a characteristic "soap-bubble" appearance in the roentgenogram as a result of thin septa extending in from the cortex. The author discusses the various theories in regard to their pathogenesis and concludes that they are probably a special localized form of Recklinghausen's disease.

These cases were operated on and a careful histological examination made of the specimens. They were followed up roentgenologically for some years. In one case the cyst was opened and curetted, in one the cyst was curetted and bone fragments put in the cavity, in one a spontaneous fracture resulting from the cyst was treated simply as a fracture and no treatment given the cyst, in the other the cyst was removed in toto and the defect filled with a graft from the tibia. There were excellent functional results and complete consolidation of the bone in all the cases. Later roentgen examination showed the cystic cavities filled with compact bone, not only in the cases that were curetted and filled with bone fragments but also in the case that was treated as a simple fracture. This shows the benign character of these cysts.—*Audrey G. Morgan.*

BLOOD AND LYMPH SYSTEM

ISAACS, RAPHAEL. Maturing effect of roentgen rays on blood-forming cells. *Arch. Int. Med.*, Dec., 1932, *50*, 836–842.

Material for study was obtained from patients with various types of leucemia, lymphoblastoma, or cancer. Observations were made on over 923 patients.

The author states that the effects of roentgen irradiation, in both large and small doses, on developing blood cells is stimulating. Cells in the myeloblastic or lymphoblastic or younger stage are stimulated to rapid reproduction, while cells in the myeloctyic or medium-sized lymphocytic stage grow through the rest of their life history and form polymorphonuclear leucocytes or mature lymphocytes respectively. Exposure to roentgen irradiation during the primitive lymphoblastic and lymphoblastic stages causes the cells to reproduce with the rapid reproduction of additional primitive lymphoblasts. Since most of the cells are in this stage in acute lymphatic leucemia, and in the terminal stage of chronic lymphatic leucemia, roentgen irradiation frequently aggravates the case of acute lymphatic or the terminal chronic lymphatic leucemia.

There is no evidence of a toxic necrotic action of roentgen rays when applied in therapeutic doses.

The period between the application of roentgen rays and the time when the cells reach

senility is the latent period. This corresponds to the time necessary for the cells to mature. The action of roentgen rays on living, blood forming cells is one of stimulation to divide or to mature in a normal manner and not one of toxic necrosis. Tissue cells which have a long adult life (muscle cells, nerve cells, and fibrous tissue cells) appear resistant to roentgen rays, whereas those that have a short adult life (germ cells and leucocytes) die soon after they are "stimulated" to develop to senility.—*W. C. Hall.*

Kramer, David W. Evaluation of various methods of investigating the circulation in the lower extremities. *Am. J. M. Sc.*, March, 1933, *185*, 402–420.

An attempt to evaluate the various methods of investigating the circulation in the lower extremities has been made in the study of 150 patients, mostly diabetics. The objectives of the study were two-fold: first, to determine, if possible, the accuracy of the subjective and objective findings of the physical examination and, second, what can be reasonably expected from the various and more recent methods of studying the circulation

The recognized methods of study of the circulation in the lower extremities are described. Readings with the oscillometer of Pachon and the histomine test were done on each patient. Roentgenographic studies were carried out in 111 patients.

The author concluded that low or zero oscillometric readings or delayed histamine reactions almost invariably point to some impairment of the circulation. In an efficient circulation normal oscillometric readings and a normal histamine reaction are nearly always found. The results of these tests on the legs were more satisfactory than those on the feet. Normal readings and histamine reactions were found in similar percentages where the evidence pointed to pathologic changes. Hypertension and the existence of a sufficient collateral circulation are offered as possible explanations. The ability of the roentgen examination to reveal early atheromatous changes in diabetic vessels and the inflammatory changes in Buerger's disease is questioned.

It is concluded from an analysis of the usual signs and symptoms which suggest circulatory disturbances that these suspicions must be confirmed by various tests for studying the circulatory function.—*Leslie Osmond.*

GENERAL

Arnett, John H., and Ennis, LeRoy M. Dental infection and systemic disease. *Am. J. M. Sc.*, June, 1933, *185*, 777–787.

The authors present a careful critique of the literature on the subject and make a contribution of their own.

Careful medical and dental studies of 883 students were made in an attempt to establish a relation between systemic disease and dental infection.

Their work shows the necessity for complete mouth roentgenograms in such investigations. Eighty-three per cent of the students had one or more carious teeth. Of the group whose histories stated that they had had rheumatism or chorea since early childhood or whose cardiac examination revealed evidence of endocarditis, 85 per cent had carious teeth, the average number of infected teeth per students being 3.3. In the normal group 82.6 per cent had carious teeth, the average number of such teeth per student being 3.2. The importance of the roentgen examination for the identification of dental granulomata, i.e., rarefying osteitis is stressed. No connection between the incidence of systemic disease and dental granulomata could be established though albuminuria and underweight were slightly more common in the group with granuloma. Electrocardiography showed no tendency toward cardiac degeneration in this group.—*P. J. Hodes.*

ROENTGEN AND RADIUM THERAPY

Mallet, L., and Pulsford, Jean. Technique of téléroentgenthérapie. Application au traitement de quelques affections du système réticulo-endothélial. (Technique of teleroentgen therapy. Application of treatment to certain affections of the reticulo-endothelial system.) *Bull. et mém. Soc. de radiol. méd. de France*, March, 1933, *21*, 280–287.

It appears evident that in affections such as the leucemias and lymphogranulomatosis which involve not one organ but more or less the entire system of the repair tissues, it is more convenient to treat the entirety of the tissues from the first manifestations of the pathologic condition than to localize the irradiation to one single area. With this view in mind, the authors constructed at the Anticancer Center of the Tenon Hospital during the

past few years an installation which permits the irradiation of the body in its entirety. The procedure is called absolute total teleroentgen therapy. It is best to use two roentgen tubes, one irradiating the front and the other the back of the body, but inasmuch as such an arrangement is often hard to carry through in practice the authors used one single tube, the patient's position being changed for the two types of exposure. According to the Lambert law, in order to obtain a homogeneous irradiation of a surface which measures about 1 meter 70 cm. in diameter the anticathode skin distance must be 3 meters 40 cm. The authors used a similar technique except that the anticathode skin distance was 2 meters, most of the patients being exposed through two anterior and two posterior fields of 1 meter diameter each. The type of radiation was 200 kv., 1 mm. Cu, 2 mm. Al, as filters, 3 ma., the doses being very small. The irradiation was applied in lymphatic leucemia, myeloid leucemia and malignant lymphogranulomatosis, several case reports illustrating the more or less average procedure being included.

The following conclusions were reached: (1) Total teleroentgen therapy is remarkably well tolerated in the leucemias. (2) Efficacious results were obtained with very small doses of 75 to 100 r, that is, with 1/20 of a skin unit erythema spaced over a month. (3) A regression of the spleen was obtained with the same doses even in cases which previously were irradiated locally with considerably larger doses without much result. This allows one to assume especially in the case of myeloid leucemia that the localized irradiation of the spleen is an incomplete procedure, not affecting the morbid process. (4) In lymphoid leucemia a regression of the spleen and a disappearance of the enlargement of the lymph nodes were obtained in one case in which the usual doses as practiced by the former technique have failed to produce any effect over a period of two years. This again proves that there is remarkable sensitivity of the tissues to the small doses even in those cases in which an apparent radioresistance to a larger doses has set in. (5) In cases of leucemia and lymphogranulomatosis, after the red corpuscles and the blood formula returned to normal, a stabilization of the process has been obtained in spite of continuation of the generalized irradiation with small doses. (6) In lymphogranulomatosis the irradiations have a favorable general effect. They produce disappearance of the pruritus and of fever and they modify the blood formula but the tumor masses themselves do not regress so that at the present time localized irradiations with larger doses are indicated in these instances.—*T. Leucutia.*

SOILAND, ALBERT. Comments on the higher x-ray voltages. *J. Am. M. Ass.*, Sept. 30, 1933, *101*, 1055–1057.

The shortest wave length now available corresponds to a voltage between 500,000 and 600,000, which equals in intensity the emanation of 500 grams of radium. The roentgen tube gives a larger percentage of absorbed gamma rays which increases its effectiveness. So much radium is unobtainable and the installation cost of the high voltage equipment is within the range of certain clinical groups. Too much must not be expected from the new voltage. There is no evidence yet available that biological reactions will increase greatly and the depth dose, while somewhat greater, is not directly proportional to the increase in voltage. A great deal of research work is necessary before any definite conclusions can be reached.—*E. W. Hall.*

BEHAN, RICHARD J. Newer concepts in cancer treatment based on research. *Penn. M. J.*, March, 1933, *36*, 401–408.

Of the twenty-six different methods of treating cancer discussed, surgery as a single means of treatment apparently has the greatest percentage of cures. Although in some cases its primary mortality is high, yet it is, in nearly all cases, the treatment of choice. Surgery plus irradiation, plus ligation, plus calcium, plus perhaps some of the heavy metals, plus desiccation and cauterization, will give the best final results in the treatment of cancer.—*W. R. Brooksher.*

BEHAN, RICHARD J. Calcium treatment of pain in cancer. *Am. J. Surg.*, August, 1932, *17*, 242–246.

Effective and surprising results have been obtained by the author, in certain cases, in the reduction, or complete alleviation, of the pain of incurable cancer by the administration of calcium. The drug is employed intravenously or intramuscularly, supplemented by an oral ingestion of 2 gm. of the substance daily. Cod-liver oil or cod-liver with viosterol was also supplied to further stimulate the activity of

the calcium. Not only is pain relieved, the use of narcotics being discontinued, but the patient actually experiences a buoyant feeling, even resuming individual activities, in many cases. Pain due to bone metastases is not as certainly or uniformly relieved as is that of cancer confined to other tissues, probably due to the fact that here pain is due to pressure. No pernicious reactions were noted, although loss of appetite and slight malaise did occur. There is a reduction in the volume of the tumor from decrease in cell permeability, which is of only temporary duration.—*W. R. Brooksher.*

Nordentoft, Jacob. Tumeur de l'encéphale avec destruction du crâne guérie depuis 5 ans par la radiothérapie. (Tumor of the brain with destruction of the cranium cured for five years by radiotherapy.) *J. de radiol. et d'électrol.*, Feb., 1933, *17*, 72–76.

The author describes in this article a case of endothelial sarcoma of the meninges with extensive destruction of the vertex of the skull which, following radiation therapy, has been cured for a period now lasting over five years. The tumor has clinically disappeared and the erosion of the skull has been closed by formation of fibrous tissue, although without much regeneration of the bone proper. The paresis of the leg which was present previous to the treatment has also improved, but it has not entirely disappeared. The treatment was carried out with deep roentgen therapy, 0.5 mm. Zn and 1 mm. Al filtration, an epilation dose having been given cross firing through four ports of entry, one on each parietal region, one on the forehead and one on the occiput. The roentgen therapy was supplemented later by physiotherapy for the treatment of the paresis of the lower extremity.—*T. Leucutia.*

Kelly, Edmund. Radium therapy in carcinoma of the lip. *J. Am. M. Ass.*, Feb. 11, 1933, *100*, 388–390.

A series of 200 cases of carcinoma of the lip treated by irradiation between 1921 and 1929 was studied. They include 137 cases with less than half the lip involved and no metastases, the others being included in more advanced groups with previous treatment or glandular metastases. Of the first group there are reported 93 per cent of two year cures and 81 per cent of five year cures. Though surgery might have cured many of these patients, irradiation gives better cosmetic and functional results with less expense and no time off from work. Surgical removal of glands is advisable in some more advanced cases, but radium and deep roentgen therapy are very effective. Deep roentgen therapy over the glands is now a routine procedure both as a prophylactic and curative measure.—*E. W. Hall.*

Talini, Pier Carlo. La tecnica curieterapica del carcinoma della lingua. (Technique of radium treatment of carcinoma of the tongue.) *Radiol. med.*, 1933, *20*, 625–659.

The author describes the technical methods of applying radium therapy in the treatment of cancer of the tongue used by the Radiological Section of the National Institute Victor Emanuel III for the Study and Treatment of Cancer at Milan. Ordinarily the treatment is divided into three stages: (1) fixation of needles and small radioactive tubes in and around the tumor of the tongue; (2) surgical removal of the regional lymphatic glands; (3) irradiation through the skin of the regional lymphatic territory by means of moulded apparatus of Columbia paste.

The general principles of radium puncture are discussed—the selection and space distribution of the needles, the duration of treatment, etc., as well as technical methods; the plans used in different cases, varying with the stage of evolution and the localization of the tumor are described and illustrated. The technique and methods of postoperative irradiation with Columbia paste apparatus are also described, giving the construction and dosage of the apparatus, the duration of treatment, etc., under different conditions.—*Audrey G. Morgan.*

Popp, L. Despre eficacitatea razelor x in tratamentul pupilomatosei laringiene. (On the efficacity of roentgen rays in the treatment of laryngeal papillomata.) *Cluj. med.*, Jan., 1933, *14*, 11–13.

Papillomata of the larynx occur especially in children, Semon in 1920 having reported 10,000 cases. They are often associated with papillomata, or the so-called juvenile warts, in other parts of the body such as trachea, pharynx, nose, lips, hard palate, skin, etc. Their etiology is not entirely clear; some investigators believe that they are produced by a filterable virus; others consider them rather as a state of irritation of the papillar layer. Clinically they manifest themselves in case of localization to the larynx by a progressive hoarseness and, if the

growth is more rapid, by stenosing signs so that tracheotomy or even a laryngotomy often appears indispensable. Sometimes they may disappear spontaneously but in most instances surgical intervention is necessary. Unfortunately operation nearly always remains incomplete inasmuch as recurrence develops soon. The author treated 2 cases by roentgen therapy, one remaining well now for one and a half years and the other for a period of two years without signs of recurrence. These 2 cases are reported in detail. The technique of the roentgen therapy was as follows: 2 fields one anterior and one posterior, 550 r being administered per field in three fractions to prevent a glottis edema. A fraction was given daily so that the duration of the treatment was six days. The quality of the roentgen rays was 170 kv., 0.5 mm. Zn and 2 mm. Al as filters, 30 cm. skin target distance. Two months later a second series was given in one of the cases whereas in the second, one single series led to the desired effect.

It is recommended that roentgen therapy be used in all children affected with laryngeal papillomas in preference to surgery. In adults a preliminary extirpation of the papilloma is advised, this to be followed by prophylactic roentgen therapy so as to forestall recurrence. —*T. Leucutia.*

NEW, GORDON B., and FLETCHER, ELEANOR. The selection of treatment for carcinoma of the larynx. *J. Am. M. Ass.*, Nov. 19, 1932, *99*, 1754–1758.

The first consideration should be to eliminate the disease, the preservation of the voice being secondary. Gross and microscopic study is necessary for determining the best form of therapy. Biopsy, if necessary, should be done immediately before operation as biopsy with delayed treatment seems to enhance the seriousness of the lesions and promote metastases. Therapeutic measures are grouped in seven divisions depending on malignancy, extent and location of the lesion. They include: (1) suspension and removal of the growth with diathermy; (2) thyrotomy and removal of the growth; (3) thyrotomy, removal of the growth and also the cartilage; (4) laryngectomy; (5) pharyngotomy; (6) foregoing procedures plus cervical adenectomy; (7) roentgen and radium therapy which may be used alone or in conjunction with surgical measures. Irradiation alone has not given permanent good results but surgery followed by irradiation offers the best method of combatting the disease. Fifty-two of 100 patients are alive and well from three to six years after treatment.—*E. W. Hall.*

LENZ, MAURICE. Roentgenotherapy of malignant neoplasms of the pharynx and larynx. *J. Am. M. Ass.*, 1932, *99*, 1840–1845.

The method of Coutard is used for roentgen therapy except that the treatment is administered more rapidly. The primary lesion and regional metastases are exposed to daily roentgen treatments through two or more areas on each side of the neck for three or four weeks. Maximum tolerance is signified by a necrosis of mucosal epithelium which precedes by a few days the denuding of the corium. A total dose of 5,000 to 9,000 r, measured in air, is given. Pain is rapidly diminished a few days after the beginning of treatment, then the tumor shrinks, bleeding ceases, the fetor oris is diminished and function is improved. Then as the mucosa swells and a diphtheritic reaction occurs pain returns and the patient becomes debilitated, dehydrated and loses weight, necessitating excellent medical care. Healing of denuded areas requires forty-seven to seventy days. Thirty-three far advanced inoperable laryngeal cancer cases were treated of whom many were improved and 7 are clinically free from cancer from six months to two and one-half years after treatment.—*E. W. Hall.*

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